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A SMALL MARKET PLACE AT TIMGAD.

THE AMPHITHEATER OF THYSDRUS.

ROMAN RUINS IN NORTH AFRICA.

ROMAN RUINS IN NORTH AFRICA.

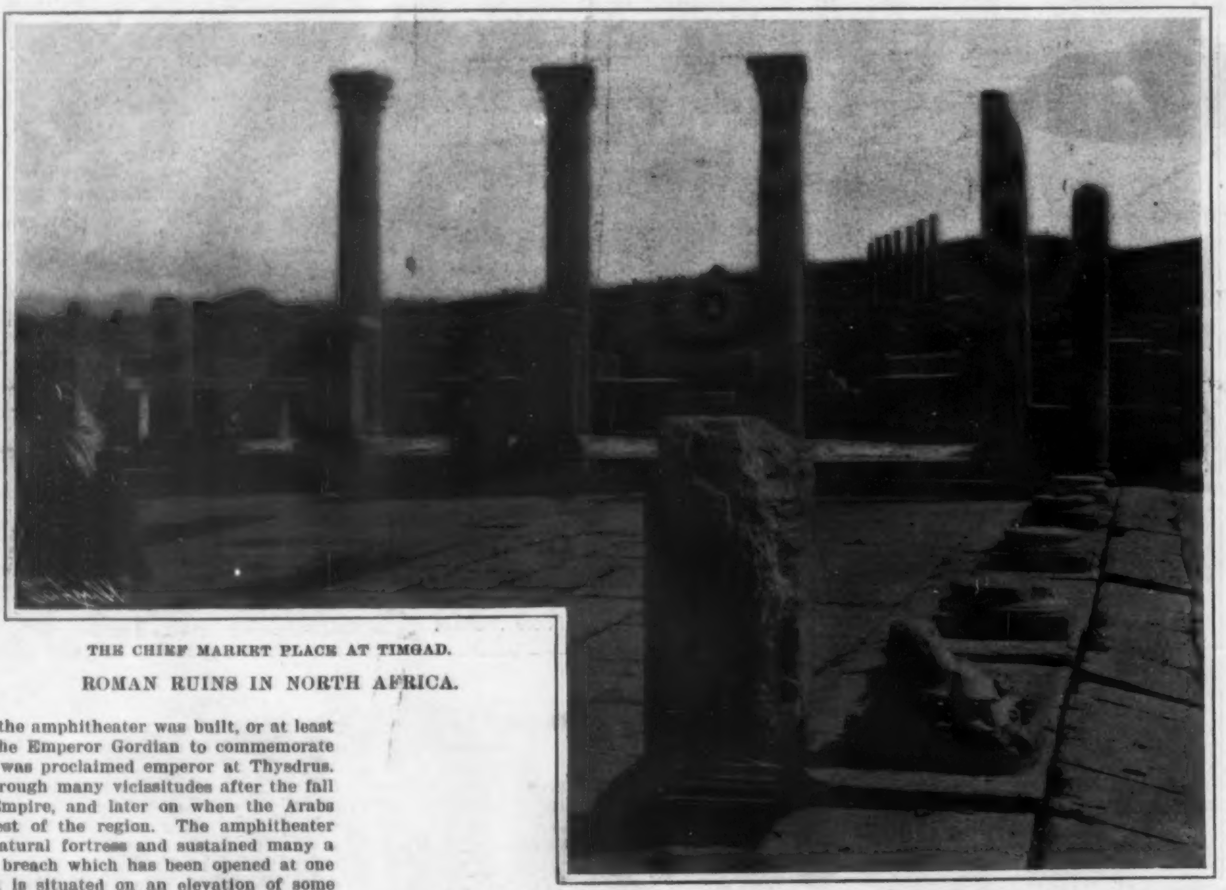
By the Paris Correspondent of SCIENTIFIC AMERICAN.

THE amphitheater of El Djem is one of the most imposing structures of the Roman period which we find in the north African region. In ancient times a large and flourishing city was located on this spot, and was known as Thysdrus. As we find in many cases, the Roman cities of the region were well supplied with theaters, amphitheaters, aqueducts, and public baths, and the remains of such structures are numerous. Although in some cases, especially near the coast, a modern town lies upon the ancient site, in others the ruins of a Roman town or even of a large city are found in the midst of a desert region and far from any inhabited locality, and it is difficult to imagine that in former times the spot was full of life and movement. In some cases the desert sands have almost covered the remains of the town, so that a veritable excavation has to be made in order to bring the ruins to light and show the topography of the place. Such has been the case with Timgad, the African Pompeii, as it is called, and also with the Roman city and military camp of Lambessa.

As regards the amphitheater of El Djem, of which we show a view, this structure is the largest of the amphitheaters in the African region; in fact, next to the Coliseum of Rome, it is the largest ever built by the Romans. As regards the city of Thysdrus, of which the amphitheater was the principal structure, we have but little record, as is the case with many other such localities, in spite of their size and importance. It is supposed that the amphitheater was built, or at least commenced, by the Emperor Gordian to commemorate the fact that he was proclaimed emperor at Thysdrus. The city went through many vicissitudes after the fall of the Roman Empire, and later on when the Arabs made the conquest of the region. The amphitheater then formed a natural fortress and sustained many a siege, as a large breach which has been opened at one side testifies. It is situated on an elevation of some height and thus dominates all the environs, contrasting by its imposing mass with the Arab village which lies at its base and has been built with the debris of the ancient city. As to its form the amphitheater resembles to some extent the Coliseum at Rome. It is a vast elliptical structure measuring nearly 500 feet long and somewhat less in width. The arena inside the building is about 230 feet on the longer axis. On the outside it was decorated with a series of arcades in three stories of which there were sixty on the lower range. The arches were upheld by Corinthian columns on the lower and the third stories, while composite columns were used for the middle range. Above the top story was a superstructure decorated with pilasters, but nothing now remains of this portion. The existing remains are over a hundred feet high above the present ground, but the ancient ground lay ten feet below this. The inside of the amphitheater has suffered considerably, as most of the staircases have disappeared and the stone blocks which formed the seats have been removed to a great extent. This structure is practically all that remains of the Roman city of Thysdrus, which lay about a hundred miles south of Tunis and not far from the coast. The aqueduct which is shown here is one of the remains of the Roman city of Cæsarea which lay on the Mediterranean coast to the east of Algiers. The town which now occupies the site is known as Cherchell. The Phenicians came to this spot in very early times and founded the colony of Iol. Later on, Juba II. enlarged and embellished the town and made it the capital of the region. It afterward formed part of the Roman possessions, and during the later periods it was destroyed and rebuilt several times. The present town occupies but a small part of the ancient site, which was surrounded by a wall and had a series of towers or forts placed at intervals. Cæsarea had two ports, the merchant port and a smaller one lying to the west which was used as a military port. Among the ancient structures of which a part are still visible we may mention the baths, which were quite extensive. Some of the fine columns of a green granite which came from the baths have been built into the principal mosque, now used as a military hospital. The water supply for the town was obtained from a spring situated to the southeast, and the present aqueduct, which was over 25 miles long, brought the water into the city. The water canal was not, however, supported upon arches except for a short portion of its length, but ran in a trench which was dug along the side of the declivity and lined with masonry. Flat stones covered it at the top. At seven miles from the town it was obliged to cross over the valley of the Oued el Hachem, and farther on it passed over the Oued Bella. At this latter point we find the remains which are shown in the present view, consisting of twenty pillars of massive proportions which supported the main arches of the aqueduct. This structure was well carried out and is built of cut stone. At a point near the town the aqueduct ended in a great reservoir which was built to contain the city water supply. The reservoir, which is divided into a number of compartments, is still in existence, although the military barracks have been built over the spot. Besides the aqueduct the reservoir was fed by canals coming from several neighboring springs. There are six water chambers of oblong form which are connected together by a series of openings in the walls. The water chambers lie parallel with each other and measure nearly 70 feet long by 25 feet wide and 30 feet deep. They have vaulted ceilings. This reservoir is in a good state of preservation and is used at the present time for the water supply of the town. From the reservoirs a large gallery which is built of brick and has a passageway on either side of the water canal goes to the building which was used for the water distribution, and from this point a number of covered canals or conduits led through the different quarters of the town.

The excavations which have been made within recent years at Timgad, the ancient Thamugadi, are most remarkable, and have brought to light nearly the whole of a large city which was covered up in the course of ages by the sands of the plain. The ruins of Timgad present a most imposing appearance, and have a certain analogy with those of Pompeii. We have already given a general description of Timgad, showing the Arch of Trajan, and some of the leading structures. At present we show a view of the Market Place, which lies not far from the Arch, and on the southern side of the main avenue. Inscriptions which have been found here seem to indicate that it was constructed by M. Plotius Faustus, a Roman of the equestrian order, and his wife. Very probably it dates from the first part of the third century A. D. Surrounding an area paved with flag-stones is a portico or colonnade which has a main entrance and two side gates. Many of the columns which bordered the inner court are still standing. They are of the Corinthian order. In the center of the court is a square basin. Opening on the area at the southern side is a wing in the form of a semicircle. It is separated from the court by a series of arcades supported upon columns. The back part of the semi-circular structure is occupied by seven niches or compartments which served as stalls of the market. The wares were exposed upon a large slab of granite which ran across each stall and was fitted at each end into the columns of the sides. The counter is only a yard high, and to enter the stall the occupant was obliged to pass underneath, as there is no other opening. The decoration of the Market Place must have been very handsome, as the remains show. Ornamented columns, friezes, and arches abound here, and a number of statues of the founder and other persons were mounted upon pedestals.

Among the latest excavations at Timgad, which have been made since our former description, we may mention the extensive baths which have been found outside the walls. The building contains no less than thirty different chambers. Among these is the frigidarium, which has a mosaic floor and three bath-pools. Around it are niches which held statues. Underneath the baths are the extensive furnaces which heated some of the rooms, and the latter have double walls to allow the hot air to circulate. In one room we find a bath-pool which is paved with a rough mosaic and has cement walls. What is curious to remark is that the walls of the pool are covered with inscriptions which have been left by the bathers. On the east and west of the frigidarium are two vast halls with mosaic pavements which may have served as promenades or recreation rooms. Other halls were no doubt used as exercising rooms. One of our illustrations shows a view of a smaller Market Place of Timgad, and in another we have an Arab hut at Lambessa with Roman remains built into the walls.



THE CHIEF MARKET PLACE AT TIMGAD.

ROMAN RUINS IN NORTH AFRICA.

RECENT GREEK ARCHÆOLOGICAL EXPLORATIONS.

THE extensive operations which have been carried out during the last quarter of the century at Delos, at Olympia, upon the Acropolis of Athens, at Delphi, and at Epidaurus have brought to light a great number of works of art, and our knowledge of antique sculpture has gained much thereby, both in extent and in precision. The most recent excavations have added also to this great collection, but especially they have furnished a great quantity of discoveries which throw light upon the topography and architecture of a Greek or Hellenistic city. This not only relates to the temples or theaters, but we may say that entire cities have been rendered to us, with their streets, their squares, gymnasia, baths, libraries, storehouses and docks. New cities like Pompeii have come to light in the Archipelago, and on the coast of Asia, and while they are not as brilliant in the way of ornament as Pompeii, they are richer in historic reminiscences, and never have the realities of antique life been brought more vividly before us than in these scenes, magnificent or domestic, where we find the traces of the ancient existence. Thus the excavations present a character which is new and original, even after those which preceded them. Without seeking to make a detailed description of the newer discoveries, we wish to dwell somewhat upon this character of novelty in the case of some of them which will be mentioned.

In Greece, the French School of Athens is at the

present time the only one which is continuing the tradition of the great excavations, at least as far as European enterprises are concerned. After the Delphi excavations were finished and turned over to the Hellenic government, the School of Athens returned once more to the inexhaustible field at Delos. The island may be said to have been gained to France by right of

ONE OF THE VASES UNEARTHED ON THE SITE OF THE BATHS.

scientific conquest. In 1876 M. Homolle, who is at the head of the French School, commenced the first excavations at Delos and up to 1894 scarcely a year passed in which either he or his collaborators did not carry on a fruitful campaign. After 1900 he wished to continue the work, but a lack of necessary funds prevented him from doing so. But the funds came to hand three years later, when the school found in the Duc de Loubat the most generous donator which it had known since its foundation. The new excavations at Delos were then organized by M. Homolle and the next year they were taken in charge by M. Holleaux and some of the members of the School.

Delos was a city which had two distinct parts, forming a double city, sacred and mercantile. It was a religious and political center and from the second century it was the most important port of the Archipelago. The first excavations were undertaken especially to bring to light the sanctuary with its temples and treasure-houses and all the different parts relating to its administration. At the same time the surroundings of the *temenos* were cleared, and here they made an interesting discovery; in the main avenue which passes along to the east of the inclosing wall they found a small chapel in the form of a rectangular niche which served for the cult of Dionysos. Not far off, they also found a statue of this divinity, in a sitting posture, and two large statues of Silenus in good condition. Besides, another find was a quadrangular stele decorated on the side faces with scenes taken from the Dionysiac legend and on the principal face we find the representation of a cock whose head and neck are replaced by the *phallos*. In the neighborhood, they found numerous pieces of colossal *phalloi* in marble, and fragments of Megarian cups with winged figures in relief relating to the cult of Bacchus. The new expedition searched especially to explore the mercantile quarter, with its ports, storehouses and docks. On the west side Delos had two gates which corresponded with the double character of the city. The pilgrim who came to make his devotions to Apollo debarked in the sacred port, which was the more northern of the two. Its entrance was marked by two large foundation bases placed in the deep water and which must have supported two decorative motifs, perhaps two tripods like those which we will speak of presently at the entrance of the port of Miletus. During the first period of the town's development the port seems to have been limited to a harbor well protected against the north winds by a line of reefs forming a natural jetty and reinforced by large blocks placed upon the reefs. The landing place lay not far from the *temenos*. Later on, when the commerce of Delos increased, the harbor was utilized to give refuge to the merchant vessels. The Romans and the Syrians of Beyrout, grouped in strong corporations under the protection of Hermes and Poseidon, possessed large

GREEK VASE FOUND AT CARTHAGE.

establishments in the region lying between the port and the sacred lake. From this quarter came one of the best groups of sculpture which the excavations yielded. It is a marble group representing Aphrodite playing with a goat-footed Pan and defended by a small Amour perched upon her shoulder. The work is of the Alexandrine type in conception and style, of an elegance somewhat decadent and an easy and a rather loose execution, but in the ensemble it is agreeable and graceful and will take a good rank among the sculpture of the Hellenistic period. The Romans and Syrians had too great commercial interests at Delos not to desire a series of docks which were nearer the center of activity than the principal port. Accordingly they chose a site between the pilgrims' quai and the end of the jetty for building their storehouses. Nothing remains of these at present, because this quarter did not cease to be inhabited during the later period and up to the Middle Ages and the successive destructions and rebuilding removed all traces of the antique parts.

This is not the case, however, in the southern region, that of the commercial port, and at present we are able to trace all the operations of handling the cargo after it was unloaded at the port. The vessel is stationed just opposite the storehouse where its cargo was to be unloaded. The spirit of individuality of the ancients is shown even in the organization of the ports. To each storehouse corresponded a special wharf, built by the trader and owned by him, being more or less extended according to need, but in any case rather narrow, so that the quais formed a continuous line, freely open to the circulation. But the line was irregular and cut up into a great number of divisions which projected unequally into the sea. The storehouses have a rather uniform arrangement. In the plan, the storehouse is a quadrilateral disposed around a central court, and in elevation it has at least two stories. The main face which lies next the sea shows in the lower story a covered entranceway placed between several oblong chambers which communicate only with the quai, and these seem to have been shops which were no doubt rented to the retail merchants so as to increase the general revenue. The remaining three sides are occupied by rooms which served as storehouses, and they are usually independent of each other and open on to the court at the ground level. The court is surrounded by a portico, sometimes upheld by stone columns, but the entablement is almost always of wood. This portico has two stories and also passes along the upper chambers. In the largest of these buildings the unit part remains about the same, but it is doubled or tripled and the inner courts are connected by a passage. It is seen at once that this construction is simple and rational, and the voyagers to the Orient are very well acquainted with it, for it exists still in the great *hans* or caravanseries, and has never changed from the farthest antiquity down to our times. At Delos the dimensions are smaller and the court is reduced for the benefit of the chambers, seeing that in this small island they were not obliged to lodge horses or vehicles.

At the same time as in the quais and their surroundings, the work of excavating was carried on in the city itself, and they uncovered a portion of the street

A HUT BUILT UP OF ROMAN FRAGMENTS.

which leads from the theater to the sanctuary. It has scarcely 5 feet in width. A sewer, covered with plates of schist, collects the water from the houses and carries it off. The street is bordered by small shops and houses, but the small size of these buildings forms an added point of interest. We are aware that the Greek houses were divided into two types, the type with the *prostas* and the form having a peristyle. The essential difference lies in the fact that the latter form of house has an interior court surrounded by a portico; on one side we enter the main apartment of the house and on the others the smaller rooms. In a general way these houses are more recent than the others and seem to represent a later development. But we cannot yet say how they passed from the one to the other form, even after the excavations at Priene and the thorough study of the Hellenistic type of dwelling which M. Wiegand made. It is not impossible that we may find out about this point at Delos. The works of art which were discovered in the course of these researches have not been very numerous. We find a statue of Poseidon, a statuette representing a goddess seated on a large throne. These are not works of the highest class, but are figures which were used for the interior decoration of apartments, such as we already find in many cases at Priene. However, they brought to light one of the finest specimens of Greek mosaic that is known as yet. It represents a winged Dionysus riding upon a tiger, and the mosaic measures 5 feet long by 4 feet wide. In spite of a certain heaviness in the proportions it remains a masterpiece by the picturesque value of the composition, the variety and harmony of the colors and the richness of the tones. A large quantity of figured and decorative stucco pieces which are often of a very fine execution, add to the collection, and gradually we find the simple and elegant decoration of the Greek house. Although they may not be as brilliant as M. Homolle's excavations, the new ones are not less fruitful, from the new facts they give us upon the private and commercial life of ancient times. They are carried on by M. Holleaux and his aids with an accurate method, followed each year by extensive reports which make

RUINS OF THE AQUEDUCT.

ROMAN RUINS IN NORTH AFRICA.

known the results at once. It may be mentioned that besides the work of the French School, a number of important excavations have been made in continental Greece during 1904 by the American expeditions at Corinth, M. Furtwängler at Egina, M. Sotiaridis in Boeotia, M. Courouniotis in Arcadia and M. Stais at Epidauros, which cannot be dwelt upon at present.

The small island of Cos, which the Turks call Istankeni, an adaptation of the Greek *is tin ko*, closes the entrance of the Ceramic Gulf. Here was the birthplace of Hippocrates, and they still show the colossal sycamore under which he held discourse with his disciples. The island rendered a widely-known cult to Esculapius, and the sanctuary of this divinity has been lately found by Mr. Paton, an Englishman. M. Herzog, professor at the Tubingen University, has been exploring it under the direction of the Imperial Ottoman Museum within a recent period. The site seems to have been visited for the sake of the temple and the baths, and worship was associated with a course of treatment, thus often bringing about the desired result, for which the deity received the credit. Nowhere else is this double character so well seen as at Cos. The sanctuary, situated at about three quarters of an hour from the city, is built on three terraces upon the hill which overlooks the sea. The two upper terraces are devoted to the worship, and at the summit we find a Doric temple of Esculapius placed from north to south, with six columns on the shorter sides and eleven on the longer. Below is a second temple which is smaller and more ancient, opening to the east side. The priests' quarters are beside it. Before the main face is the altar, which with its portico, its denticulated cornice, its compartment ceiling, is like a miniature reduction of the great altar of Pergamos. Beyond is an Ionic temple constructed at the Imperial epoch upon the tufa substructure of an archaic edifice and no doubt devoted to the cult of the emperors. Upon the lower terrace the worship gives place to the bath treatment. The space is larger here and in the center it is occupied by a porch which served as a place of assembly for the patrons of the baths, and here the small *ex-voto* images which continue to form an important object in worship, were sold. At the northeastern side were found the bathing houses and all around were a series of chambers or veritable bath-cabins which received a good supply of water from a spring placed about 300 feet above the top terrace. Along the terrace wall were a number of wells and cisterns for drinking purposes. Thus we find that nothing was lacking for the internal and external treatment.

Among the works of art which have been brought up during the last three years at Cos, we may mention a head bearing a casque, which seems to be of the Alexandrine type. It is in a remarkably good state of preservation, although the upper part of the head was partly restored. The hair is very well executed. Here, as at Delos, the best part of the finds have been topographic and in the way of inscriptions. One of the inscriptions has a special interest in one way as it relates to the expedition of the Gauls into Greece, and forms the most ancient authentic record of the history of France. The inscription is a decree of the people of Cos, who decided to celebrate the defeat of the Gauls before Delphi and the protection of Apollo by a double sacrifice at Delphi and at Cos. Among other archæological work in Greece may be mentioned the exploration of the Acropolis of Lindos, in the island of Rhodes, by two Danish savants, Messrs. Blintenberg and Kinch. Inscriptions form the greater part of the objects which they have brought to light.—Revue de l'Art Ancien et Moderne.

THE POSITION OF PATTERNS IN THE MOLDS.

By WALTER J. MAY.

IN the usual practice of the foundry, the molders are given patterns and told to make so many molds, it being largely left to the individual worker as to how the patterns are arranged, unless some special order is given to the foundry. This works out all right as a rule, but where special work has to be done, it at times happens that the best results are not obtained, so far as other departments are concerned.

It must always be borne in mind that with molten metals there is always some chance of having faults when cooled down, and some little attention should be paid to this, while in addition there is the chance of getting blow-holes and porosity in some parts of all castings. The reasons for these blow-holes and porous parts are several, and may occur through something in the metal, or through faults in the melting, the causes not always being the same. Anyway, they occur; and if care be not taken in the molding, they occur in places where they spoil the castings. Of course, the faulty castings can in most cases be "filled," or otherwise faked up; but it is better that faults should not occur.

The bottom side of a casting is always the most dense part, and, as a general rule, it is free from faults and blemishes, and for this reason it is always better to cast articles which are to be partly machined with the machining sides downward. With some things this, of course, is impossible, and in such cases it is necessary that special care be taken in regard to the quality of the metal, and beyond this the sand and other materials should be beyond suspicion. Even then, there are some points of a practical nature which should be attended to, such as the provision of "risers" into which any dirt or sullage can ascend, the provision of places through which a quantity of the metal can wash out along with any dirt and sullage, and so on.

Taking a common form of casting as an example of a thing presenting minor difficulties, we may select an ordinary angle plate. This usually has to be planed on the outer sides, and, of course, must be clean. While being rather full of cored holes, it is rather difficult to deal with if the prints are fixed on, as these will break the sand away in lifting the pattern. Either the prints should be on one side and

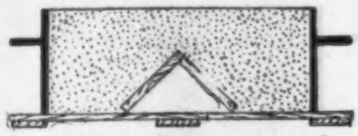


FIG. 1.

held with pins or screws of an easily removable nature, or core prints should be avoided altogether, the latter being best, in the opinion of the writer. These things are best cast with the angle downward, so that the planed surface shall be the best, and the method of molding should be as follows: The pattern is placed on a board, as shown in Fig. 1, and the drag rammed up. This is then turned over

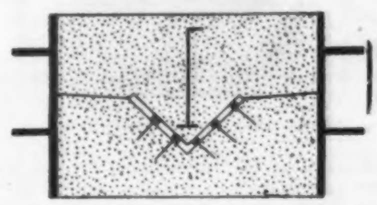


FIG. 2.

on a soft bed, the board removed, and the joint smoothed off and made, the cope then being put on and rammed up, being careful to have sufficient irons to hold up the sand. On the hanging sand the cores should be fastened with a couple of wire nails through each one, and then the mold—having previously made the runner and a couple of risers at the opposite end—should be closed and poured. If molded with ordinary care there will be no trouble in the fit, and the mold will appear as in Fig. 2. If core prints are used they

FIG. 3.

should be on the inside of the pattern only, and should be loosened and left in the mold while taking off the body of the pattern, and then afterward be lifted out, the cores dropping into place and requiring no nails. In this case the mold will either be cast angle uppermost, or the flask will be closed and then turned over, either plan being adopted at the will of the molder.

Another awkward piece to cast is where two fairly solid and heavy parts are joined by a thinner piece bridge fashion, and this wants some care; otherwise

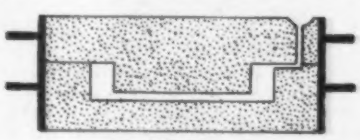


FIG. 4.

the connecting portion will break in cooling. Of course, the bridging piece must not be too thin; but, assuming it is somewhat in proportion as shown in Fig. 3, if cast with the bridge downward it will come out all right. The method of molding is shown in Fig. 4, and this scarcely requires any explanation. The hanging piece must be well held by irons to prevent its dropping, and should not be rammed harder than is necessary, some little attention being given to the contraction of the metal during cooling. Such things also require feeding as a general thing, but

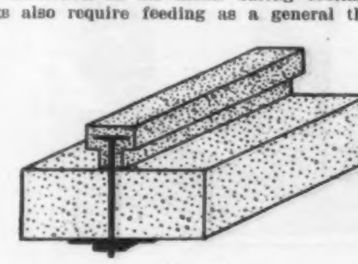


FIG. 5.

this is rather a matter for individual practice, both in regard to methods and class of metal used.

In all cored work it must be remembered that the cores have a tendency to rise, and for this reason all cores coming in the bottom of molds must be very firmly fixed. Various plans are used for this fixing, among them being plates bedded in the cores, from which screws depend, as shown in Fig. 5, and cores with conically-shaped print ends.

Cylindrical castings should, where possible, be cast on end, as shown in Fig. 6, the cores only needing a bottom print if the core is long enough for the top of the mold to bear on it a little; but too great a length should not be allowed. Cylindrical castings, when cast on their sides, are denser on the bottom side as cast; but many things are cast on their sides as a matter of convenience, but these are always denser, and are very often thicker on the bottom side. This difference is felt both in boring and turning, but is unavoidable.

Casting metal on to wrought rods, etc., is always more or less difficult, and, where possible, the work

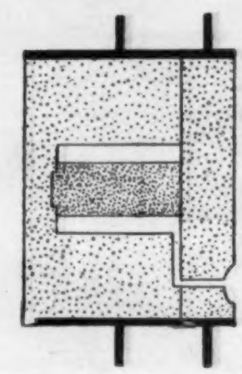


FIG. 6.

should be done on end, ample length for cutting off spongy metal being allowed, this allowance, of course, being on the upper side, or end, of the metal cast on. Usually such work requires two casts, the first one being spongy or porous, but the second one coming sound and fit for machining after it is cast over the porous one. The iron forming the center of the pump-plunger, or whatever the article may be intended for, should be cleaned up bright and then tinned to cause the best and soundest work, and then after the mold is made the two halves of the flask should be clamped round the rod previously fixed in position, and the metal poured. Wooden patterns for the molds will be used, and special flasks will be necessary; but a good idea of the arrangement of the flasks and molds will be gathered from Figs. 7 and 8. The method of suspending the rod is one which the conveniences at hand will suggest; but so long as it is rigid, that is the chief point. Of course, a good many things of this kind are cast flat; but in regard to this method it has to be borne in mind that one side is harder than the other, owing to the difference in the density of the metal at different heights in the casting.

Sliding parts doing heavy work should always be cast with the sliding side downward if the greatest

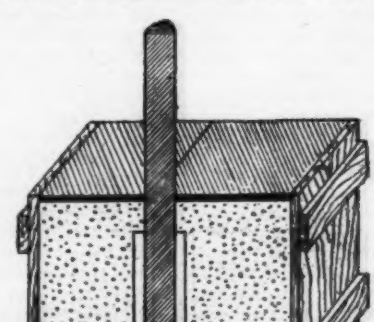


FIG. 7.

resistance to wear is desired, and this simply because the bottom of the casting is more dense and compact. Take the crosshead slide of an engine as an example. This usually has to stand really heavy wear, and the closer the metal the better. Necessarily more labor is needed in working up the face of the slides when thus cast; but the durability is increased by years. The same with the sliding blocks, the bottoms of which should always be downward in the molds. Of course, this causes more trouble in inserting the cores; but even this can be avoided if there is a hole in the side of the box for the runner, and a loose cup is used for the pouring head. Clamping boards will be necessary when casting this way; but the molds can be made in the ordinary way and then set on end. Figs. 9 and 10 show a side and end section of the mold for a block cast in this way, and need no description.

Coming to another form of casting which crops up at times, chilled castings need care as to the position of the chilled parts in the molds if the depth of chill is to be uniform. Small castings are now being referred to, because rolls and such-like heavy work will not trouble the ordinary foundry. A chilled

casting is made from a special mixture of chillable iron, and must have a tough non-chilled heart or back, according to the purpose to which it is to be placed. Hardness and leveliness of the chilled portion and toughness of the unchilled portion are what is needed, and, therefore, the molds must be made to give this effect as much as possible. The chills are usually

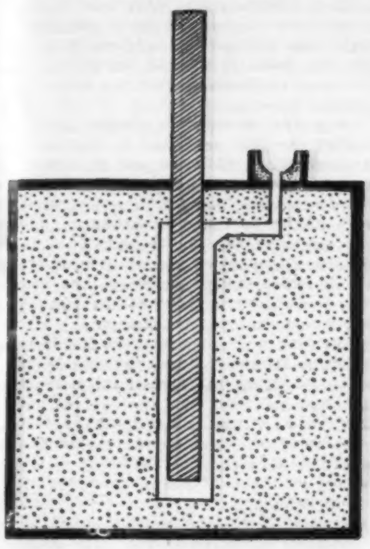


FIG. 8.

of cast iron, and, taking a cart-axle box, the inside will be on the chill, while the outside will be against the sand of the mold, as shown in Fig. 11. Inside chills of this kind are, of course, tapered, and where oil chambers are wanted in the axle-box, bands of loam are struck on, the bearing parts being against the chill, and if this is clean, little or nothing has to be done to the chilled part of the casting. Such things as these should be cast upright, the pouring being done quickly, as otherwise there will be uneven chilling. When cold the chill is driven out and the casting cleaned up, in some cases there being a little grinding done to the chilled face. Flat chills for large surfaces are usually placed in the bottom of the molds, and are of some thickness—say, 3 inches or more—or their effect is much diminished. Water chills are for some

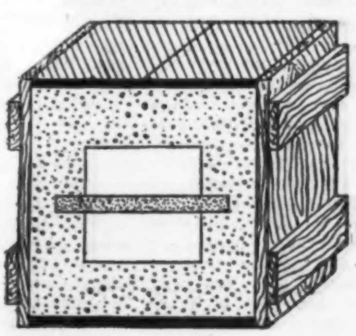


FIG. 9.

purposes more suitable than those of solid iron, and necessarily these must be on the top of the molds. Wheel chills are simply thick rings of iron imbedded in the molds, and according to the thickness of chill needed so is the thickness of the chill and the mixture of iron used varied. A good Bessemer hematite gives a good chilled casting, and the chill can be modified by adding a soft iron, such as Gartsherrie No. 3 foundry pig. Inside chills for rings chilled on the inside should be sawn nearly through at about each ½ inch, to permit of the contraction of the casting not breaking it asunder; but as these things may never be wanted in an ordinary foundry the process need not be illustrated. Plowshare tops are usually made partly

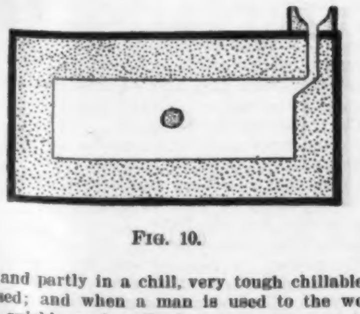


FIG. 10.

in sand and partly in a chill, very tough chillable iron being used; and when a man is used to the work it is done quickly and well; but to a stranger to the work they are rather awkward.

Previously the difference in density of metal in various parts of a casting has been mentioned, and one effect of this is to cause curvature in some kinds of castings which otherwise should be straight. In many cases the straightness of the castings can be maintained by keeping the part exercising the most strain to the top of the mold, as usually the denser portion contracts most. Of course, the molder can exercise some control over this by the way he rams up the mold; but this is not always sufficient wholly to prevent the curving action of the contraction of the metal.

With a large number of alloys thick castings are found to vary in content from top to bottom, the heaviest component metal more or less sinking and drawing away from the lighter metals. In such cases the molds should always be cast in their thinnest positions, and should be cooled off as rapidly as possible. Besides this, where possible, another metal should

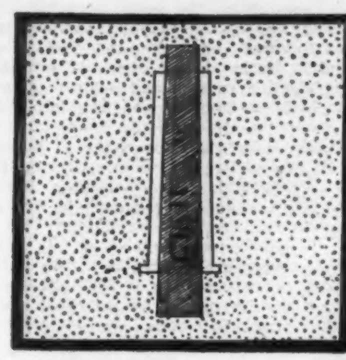


FIG. 11.

be added to the alloy, and this should be a metal with which the partly separable metal will intimately alloy, and also which will reduce its specific gravity. In some cases some fluxing material will be of a little use; but, generally speaking, only some change in the actual composition of the alloy is of practical value.

Small pipe castings are usually made on the side, and in very many cases the cores have to be supported by nails or chaplets. In straight work the cores have to be firmly held at the ends, and with long lengths have to be supported, great care being taken to prevent the cores rising. Wherever nails are used, it is well to make a slight boss on the outside of the casting as this tends to soundness; but with different molders slightly different practice prevails in this matter. Roughly, the position of the nails and core is shown in Fig. 12, and in both pipes and hollow columns the practice is practically the same.

Where chill molds are used, as in bedstead work, they are arranged to occupy certain positions, and should be poured in those positions. The question of the hardness or softness of the castings wholly de-

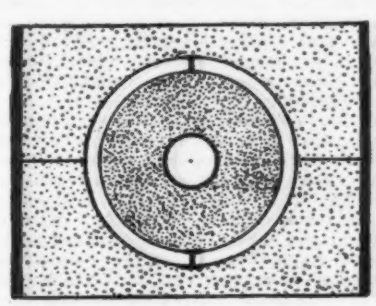


FIG. 12.

pends on the kind of metal used, and, speaking from a general point of view, soft non-chilling iron should be used for this work. If chillable iron or scrap iron be used for chill castings, it will be hard and brittle—in fact, unworkable with files or ordinary tools. Chill molds work all right with brass and soft metals, however, if the metal is run in a fluid state and the molds are coated with plumbago or other good facing; but they should be poured the deepest way and the metal dropped in rapidly.

In arranging groups of patterns in one flask, they should be of practically similar form and size, or there is a great chance of some robbing the others. If, however, each mold is poured separately, this will not occur, and there is then no objection to utilizing

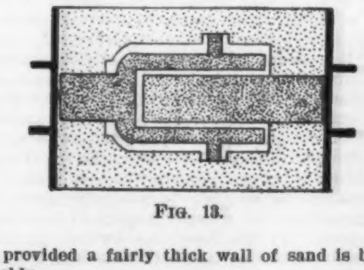


FIG. 13.

space, provided a fairly thick wall of sand is between the molds.

Complicated cores sometimes cause trouble in arranging the best position for the patterns, and where cores are held and balanced from the end, very great care is necessary that the prints fit, especially when nails cannot be used, and the print ends must be of ample length. The work necessitates the use of larger flasks than would be necessary if the cores are supported at each end, and much more care is needed in fitting the cores. The method of fitting balanced cores is shown in Fig. 13, and the sectional drawing requires no written description. Advantage should be taken of any cross cores for the purpose of steadying the main cores, and in cases where such can be used without injury to the casting, nails may be used as additional supports.

Small cylinders for motors should be cast on end with the explosion end downward, so as to get the densest and strongest end where most strength is needed, as the pressure per square inch decreases as the piston is forced forward. Probably the turner will not like this, but his wishes can scarcely be considered in the matter.

Gilled castings, unless flat, should be cast on end, and where flat should be cast with the gills downward as a rule. If the iron mixture is one which has more than the usual amount of contraction, the method of casting may be reversed; but a small riser should be on the end of each gill or rib, the flask sloping upward from the pouring end; otherwise dirt may cause a somewhat faulty casting.

Wheels are always cast on the side; but these will not often bother the small foundry, as special firms cast wheels and pulleys as the bulk of their work, the molders being experts in this class of molding. The same may be said of stove-pipe and rain-water goods, all of which are specialized.

With aluminium and its alloys the chief thing in arranging the patterns in the molds is to put them in such a position that when poured the mold fills rapidly and completely, as very little will make the castings run up faint. There is not much difference in the density of the metal in any part of the casting unless it is excessively thick, and this is not likely to occur very often, especially with aluminium alone.

Many flasks, after being molded, will have to be poured on end, or may be poured when placed in an inclined position; but this does not largely affect the position of the patterns in molding further than the arrangement of the runners and ingates are concerned, and these are points on which the molder must himself decide.

As to the patterns themselves, they should be made with a view to being as convenient as possible to the molder; where this is the case it is usually found that better molds are produced as a rule. Often solid patterns are provided where they should be in two or more pieces—a small enough matter in itself, but one which is frequently the cause of the mold being arranged to give the best results in the casting. Patternmakers are not molders, however, and the required position of the pattern in the mold should always be shown where either finish or wear in the cast article has to be provided for.— English Mechanic and World of Science.

SOME INTERESTING FACTS ABOUT BRAKES.

IN a paper appearing in Tram. Rly. World, C. L. C. Fell enumerates the most important types of brakes as follows: (1) Hand brakes; (2) mechanical slipper or track brakes; (3) pneumatic slipper or track brakes; (4) air brakes; (5) momentum brakes; (6) emergency electric brakes; (7) rheostatic brakes; (8) electromagnetic disk brakes; (9) electromagnetic track brakes. Each of these types is first briefly described, and, after eliminating those which are inadequate to dense-traffic requirements, the author pronounces in favor of electromagnetic track brakes. The momentum brake is, however, quite effective, as is shown by curves and test results. In considering the value of any braking apparatus, attention has to be paid to the following, which are enumerated in the order of their importance: (*a*) Reliability; (*b*) facility of operation; (*c*) rapidity of application; (*d*) distance necessary to stop after brake is applied; (*e*) length of time current is passing through motors and brake coils, viz., the ampere seconds; (*f*) first cost; (*g*) cost of maintenance. In congested traffic, as in London, it is of primary importance to have a brake which will stop a car in the *shortest possible distance, especially at the lower* speeds. The majority of accidents occur when cars, not fitted with electromagnetic track brakes, are running at the lower speeds. Provided the conditions (*a*) and (*b*) are fulfilled, items (*c*) and (*d*) may be taken as a direct measure of the value of the braking apparatus. Condition (*e*) refers to the electrical equipment of the car, and is an indication of the deteriorating effect due to the electric or magnetic brake. The increase in schedule speed which is safe when effective braking apparatus is employed insures (1) better service with fewer cars, so that capital outlay on cars and car sheds, etc., is reduced; (2) cost of operation per car-mile much reduced, as fewer motormen, conductors, inspectors, and cleaners are required. The cost of upkeep per car is somewhat higher, but, as fewer cars are in service, the total cost is not greater. For cars driven at higher speeds (within reasonable limits) the total cost of power is not materially increased; although more power is required for rapid acceleration, a car will coast a greater distance without power being applied. The efficiency of the motors being, as a rule, higher at the increased speed, it simply becomes a question of supplying a large amount of power efficiently for a short time or a smaller amount inefficiently for a longer time. The latest forms of electromagnetic brake can be used in the thickest traffic at very low speeds. In the designs with longer magnets the ampere-seconds are very much lower, and the motors are not overheated. If these brakes are adopted, several important points require attention. The controller should be designed with not less than seven brake notches, so that the brakes may be applied gradually; also the brake connections in

the controller should be entirely disconnected from the power circuit. The controller connections also have to be arranged so that when one motor is cut out the brake winding will not be short-circuited. Electromagnetic track brakes are useless if applied at junctions where manganese steel rails and special work are used throughout; the new brakes are also very powerful in their action, so that great care has to be exercised in teaching motormen how to use them. The cars to which these brakes are fixed should be substantially built, especially when roof covers are fitted, as the strain caused by the rapid application of the brakes at high speeds may develop serious defects.

REMARKS ON SOME OLD-TIME ENGINEERING.*

By T. C. MENDENHALL, Ph.D., LL.D.

To one who sojourns for a few months in the valley of the Nile, new interests are constantly springing up. Impressed from the start with the profound historical and archæological significance of the ruins by which he is surrounded, a very superficial study of them suggests difficulties of construction and interesting engineering problems, especially if the quantitative side of his mind has had a "square deal" in his intellectual development. Many, indeed nearly all, of the numerous writers about Egypt have touched upon these problems, but the subject has not yet been adequately treated, doubtless because of the lack of an investigator combining in himself the peculiar training and philological skill of the archæologist with the scientific discipline and soundness of judgment characteristic of the engineer. Since aggressive investigation of Egyptian antiquities began about three quarters of a century ago the archæologist has mostly been in the saddle. During the past twenty-five years, practically since the British government has administered the internal affairs of Egypt, the engineer has been coming to the front.

The other day I saw an illustration of the kind of harmony that has existed between these two. About six miles south of Assouan and two above the first cataract of the Nile is the small island of Philæ. It is about a quarter of a mile long and five hundred feet broad, and it is covered with the remains, some in very perfect condition, of ancient temples, dedicated to the worship of Osiris and Isis. The earliest of the existing foundations were probably laid about 400 B. C., the others belonging to the Ptolemaic period. The island was always regarded as peculiarly sacred, being spoken of in early records as the "Holy Island" or as the "Interior of Heaven." Such parts of the temples as are still upright and visible are among the most beautiful architectural remains in Egypt. Some additions to its collection of buildings were made during the Roman occupation and the beautiful "Kiosk" or "Pharaoh's Bed," as it is popularly called, has upon its walls fine reliefs depicting the Roman Emperor, Trajan, in the presence of Isis and Osiris, an interesting link between ancient and modern religions. Naturally this island has been highly regarded by the archæologists, whose veneration for it has been different in kind but, perhaps, not less in intensity than that of the Egyptians of two thousand years ago. As recently as two years ago one might wander over the island, study the ground plan of its temples and enter the most sacred precincts of those still standing. But now—alas! it is not so. I saw only such parts of the ruins as were above ten or fifteen feet of water, the island itself being entirely submerged. My boat was skillfully guided among the columns, gateways, porticos and pylons and I felt amply repaid for my trouble; but there is no longer the island of Philæ, except for a few weeks in the summer, when a nearly vertical sun, with the desert all about, bars the ordinary traveler. Leaving the "Interior of Heaven" (not entirely without hope of some time seeing it again) we were rowed down the river for about two miles and put ashore on the left bank. Before me stood the greatest triumph of modern engineering in Egypt; a really stupendous work and the first of its kind in the world, the Assouan Dam. Begun in 1899, finished in 1902, filled for the first time during the flood of 1903, this dam holds back the water of the Nile until it fills an enormous storage basin above the first cataract and by one hundred and eighty gates controls the flow of the mighty river so as to distribute the annual flood more uniformly in time. But notwithstanding its value in the development of the agricultural resources of Egypt (and agriculture is the sole resource of the nation) this dam is the *bete noire* of the archæologists. When it was first proposed there came a loud cry from the "sentimentalists" (the same who complain of the Italian government because it has cleaned Rome and made it decent and wholesome, at the expense of a few relics of antiquity) that it must not be built because it would flood and eventually destroy Philæ. The engineers suggested that the ruined temples might be removed bodily, and set up just as before on higher ground near by. This plan was not acceptable, and a compromise was effected by which the height of the dam was made to be several feet less than originally intended. And the result is this—the temples are submerged during several months of the year to a depth of twenty or twenty-five feet; the effects of the action of water upon them are already visible and there is little doubt that before many years they will be seriously impaired, if not entirely destroyed; the dam does not hold the water high enough to accomplish the ends for which it was built (at a cost of about $12,000,000) and already plans have been prepared for raising it twenty feet above the present height, still further flooding the temples and hastening their destruction; the cost of the addition to the dam will be vastly greater than if it had been built according to the original plans—it is doubtful if the temples could now be removed, and so nobody is happy.

* Journal of the Worcester Polytechnic Institute.

What an archæologist can do when he undertakes a bit of engineering work may be seen in more than one place in Egypt and especially at the rock tomb of Amenophis II. of the 18th dynasty, which is in the mountains on the west bank of the Nile at old Thebes (Luxor), where so many royal sepulchers are found. These tombs are cut in the solid rock of the mountains, the chamber containing the sarcophagus of the king being reached by passing through narrow corridors often three hundred to six hundred feet in length, seldom straight in horizontal plan and generally descending by steep steps and long inclined planes to a level as much as one hundred and fifty feet below the entrance. There is, therefore, an unavoidable expenditure of energy in getting into and out of one of these tombs sufficient to satisfy an ordinary person. But the archæologist in Egypt is an extraordinary person and just before the entrance to this tomb he has erected of brick and wood, a steep, double stairway, which one must climb up and down in order to get in or out. I examined this structure with some care, hoping to find a reason for substituting it for the easy grade which nature and the old tomb builders had made possible but I could find none. To one who is, unfortunately, so sensitive to "grades" that he is almost a level of precision, such a flight of steps affords food for thought. What a marvelous creation is such an archæological engineer! On one side of his intellectual equipment so acute and scholarly, on the other so abysmally idiotic! I have no doubt an engineer-archæologist would shine with equal brilliancy.

The engineering of ancient Egypt was almost exclusively confined to architecture and it is to be studied only, or at least principally in the surviving ruins of tombs and temples. In those days when a man, for one reason or another, had come to be "somebody in particular" he at once set about building a tomb for himself.

If he had a good supply of men under his lash he also began a temple or, as often happened, he contented himself with adding to or altering some already existing structure, usually erasing therefrom the name and "graven image" of his predecessor and substituting his own instead. Sometimes this was the only "improvement" made and this ingenious way of acquiring fame possessed such merit that after the lapse of several thousand years it is still extensively practised, in spirit at least, in all parts of the civilized world. As to the domestic architecture of the ancient Egyptians, unfortunately almost nothing of it remains. Such evidence as exists seems to indicate that the private dwellings of the rich and even the palaces of the kings were greatly inferior in material and construction to the temples, often being built of sun-dried Nile mud bricks, as are the great majority of houses on the banks of the Nile to-day.

In visiting their wonderful tombs and temples one's mechanical sense is greatly impressed by the exquisite skill with which the hardest materials have been wrought. There is much carving and manipulation of alabaster, black and red granite, and one might almost say "acres" of low-relief work in pictorial and hieroglyphic art, on a very fine-grained and hard limestone. Little is known of the tools used or of their methods of working such material. Metals, iron especially, were scarce and costly, but without considering processes, in delicacy of outline and beauty of polish nothing better can be shown in modern times. The perfection of their ornamental metal work and their apparent familiarity with all of the technical operations in working gold and silver, in enameling, etc., are established by the many examples found in the tombs of their kings and queens. This makes it all the more startling to find in the same place flint knives of great beauty of finish and furnished with handles of gold plate, an evidence of the high esteem in which they were held.

While not lacking in appreciation of the beauty of this work the dynamic engineer must be most interested in its magnitude. Enormous masses of stone (monoliths) were quarried, shaped, transported long distances, sometimes more than six hundred miles, and placed where it would be difficult to put them by means of the most perfect modern appliances. Practically all of the granite found in nearly every tomb and temple in Egypt came from the famous quarries at Assouan, over seven hundred miles south of Alexandria. It is found in statues of colossal dimensions, in their massive pedestals, in huge sarcophagi, in obelisks, and it often constitutes a considerable part of the structural material of their pyramids and temples. There is, for example, the colossal statue of Rameses II. in one of his temples on the west bank of the Nile at Luxor. Concerning this king, who is often assumed to be the Pharaoh who drove Moses from Egypt, and still oftener thought to be the father of that enemy of the Israelites (which is, perhaps, still worse) it can be truthfully said that he was the greatest temple builder and the vainest man known in history. Vain, because he was constantly setting up statues of himself in all parts of his kingdom, and when his "artists" failed to produce them fast enough to suit him, he set a lot of workmen at the statues of his predecessors, having their names chiseled out and his own cut in. Besides building new temples he enlarged and restored old; wherever there was a little blank space on a column, pylon or gate he had his "cartouche" engraved, and so industrious was he in this that the traveler in Egypt hardly knows his own signature better than he does that of Rameses II.

The colossal statue referred to is now broken in fragments, but enough of it remains to enable one to make a fairly good estimate of its dimensions. It is thought to have weighed about one thousand tons, or 2,000,000 pounds. From a rough measure which I made of the pedestal on which it once stood I infer that it alone weighed not less than half a million pounds. It is a rectangular, monolithic block of black granite and with the statue (also monolithic) must have come from the Assouan quarry, about one hundred and fifty miles further up the river. The well-known "Colossi of Memnon," not far away, were originally no less massive.

But the scores of colossal statues scattered over the valley of the Nile are small in number compared with the sarcophagi, hollowed out of huge blocks of granite or limestone and generally beautifully carved within and without. Some of the largest and most interesting are to be found at Sakkarah in the Apis tombs, or tombs of the sacred bulls (not to be confounded with the Papal bulls of a later era) where they rest in subterranean chambers reached by corridors cut for hundreds of yards through solid rock, the passages being barely wide enough and high enough to allow them to pass. One of these enormous granite coffins now, pathetically, blocks the way in one of the side corridors. It never reached its destination; the mummied body of the last sacred beast stopped a little short of what was meant to be its final resting place; the stranded sarcophagus marks the end of the worship of Apis and the beginning of a new cult.

There are also the obelisks, those beautifully designed monolithic "needles" of red or black granite which the early Egyptians were so fond of erecting before the gates of their temples. The Romans stole many of them and three of them now ornament public places in the three chief cities of the modern world, London, Paris, and New York, but a few excellent examples remain with their graceful hieroglyphic inscriptions as clear and clean as if cut but yesterday. The tallest known obelisk is that now standing in front of the Lateran Church at Rome, its height being one hundred and five feet; and the next highest is that still standing before the fourth pylon of the great temple of Ammon at Thebes. It is of beautiful pink granite ninety-seven and one-half feet high and nearly nine feet square at its base. Each of these must weigh near three-quarters of a million pounds.

Finally, there are the pyramids, in many respects the most remarkable of all the tombs of Egypt. The form and dimensions of these are so well known that description is unnecessary, but in considering the engineering problems involved it is worth while to remember that the base of the largest, the pyramid of Cheops at Gizeh, covers an area of about thirteen acres; that it rises to a height of over four hundred and fifty feet, and that it contains about 3,250,000 cubic yards of solid masonry. Much of this is in the form of solid, rectangular blocks, accurately worked, of limestone from the Mokattam Hills, ten miles away, and on the opposite side of the Nile. The finishing or exterior coat, now entirely gone, was doubtless of granite from the Assouan quarries, smoothly dressed and polished. A hint as to the solidity of the structure and the skill with which it was originally put together is given in the statement that when the building of the first great dam across the Nile a few miles below Cairo was begun, about seventy years ago, the then ruler of Egypt, Mohammed Ali, indifferent alike to the memory of his predecessors and the protests of the world, ordered that the stone for its construction be taken from this pyramid; but a trial proved that it was easier and cheaper to take it fresh from the quarries. Some of the huge blocks of stone in this pyramid weigh as much as sixty-five tons, and the largest are found at a level far above the center of gravity of the whole mass, being above the "King's Chamber," the roof of which is composed of nine enormous slabs of granite, each about twenty feet in length. Much has been written of the marvelous workmanship displayed in the jointing and polishing of the fine-grained Mokattam stone used for the most part in the construction of this pyramid; nothing surpassing it or even equaling it is to be found in modern structures, for "neither a needle nor even a hair can be inserted in the joints."

The question, then, which a sight of all of these splendid monuments of an early civilization suggests to one sensitive to dynamic influences is—How did they do it? Without considering their wonderful skill in quarrying and working all varieties of stone, by what processes were they able to transport and put in place such huge masses? What was the power and what the machinery made use of? Many people have suggested answers to these questions, and while I am not ambitious to add to their number I may venture to call attention to certain conclusions which seem to me to be necessary in view of existing conditions and well-established historic facts.

To begin with, some light, but not much, is thrown upon the subject by pictures and inscriptions of ancient tombs and other monuments. While often rich in the details of the operations of agriculture, domestic life, the simpler mechanic arts, etc., in only a few instances do they show anything of the more difficult constructive processes, but the negative evidence which they furnish, together with the almost certain fact that no really great invention could ever be entirely lost, shows that they could never have used the "right and left hands" of the modern engineer, steam power and explosives. The physical hydrography of the Nile puts water power, except in a very secondary way, and for purposes of transportation, out of the question. The

same may be said of wind power; so that the conclusion is easily reached that "muscle" was their primary source of power. Because of the great density of population, a great proportion of which was held in slavery, and because the cost of maintaining an ox was probably as great as the "keep" of five or six men, the food of ox and man being essentially the same in quality, it seems certain that the muscle employed, especially during the earlier period, was almost exclusively human muscle. Buckle declared that the heat of the Egyptian climate not only renders clothing unnecessary but at the same time diminishes the appetite, thus lowering the cost of mere existence to near the irreducible minimum. Although the "fellahin" are no longer slaves, aside from the sentimental aspect of the case, their condition is not greatly different from that of their ancestors. The other day I saw a hundred or more of them put on board of a Nile steamboat to be carried to some distant point where they were to work on a canal under construction. Besides the clothing which he wore, scanty enough, each man bore upon his back a huge sack filled with fragments about as big as an orange of something that turned out to be bread of the cheapest and poorest quality. This was all he would have to eat for perhaps several weeks, and when it was gone he must manage to get another supply from the village he was leaving behind. The government or the contractor employing him took no thought of his physical welfare and made no provision for his eating or sleeping in the desert-like region in which he might be working. His bag of bread, softened by dipping it into the muddy current of the Nile, must satisfy the first requirements, and as for sleeping, he needs, or at least makes, no bed, wrapping his thin cloak about him and lying down under a cloudless sky wherever night finds him. For his labor he is paid about twelve cents for a long, tropical day. Under such conditions it is not strange that as a source of "foot-pounds" neither ox, nor ass, nor camel can drive him out of the market. British coal is lately trying its hand in competition with him, but with doubtful success.

As to mechanical devices by means of which this almost inexhaustible source of power was utilized we cannot be so certain. That most of the simple and a few of the more complex forms of machines by which force may be applied, directed, and multiplied were known to the early Egyptians seems to me to be completely proved by existing, visible evidence. Few things are more frequently figured in tombs, on temple walls, etc., than the balance, "in which the heart is weighed." Its prehistoric use is shown by the fact that it is found in the "Book of the Dead," which is said to have been old in the time of Menes, the first known king of Egypt. That it sometimes appears with one arm longer than the other indicates that the multiplying power of the lever was understood. Indeed, the lever must be regarded as the most elementary of mechanical devices and instances are not wanting of its apparently pre-meditated and intelligent use by monkeys. All historic inquiry in Egypt is rendered less difficult than it otherwise might be, by the wonderful conservatism in habit and mode of life of its people. This is doubtless due, in large measure, to the peculiar and almost unvarying regularity in the regimen of the great river upon which its continued existence depends.

Egypt is the daughter of the Nile, and the mother of geometry (in its larger meaning, the science of earth-measuring). But Egypt must also have been the mother of at least one of the earliest of human inventions, a simple but effective device by which the relationship of the mighty river to her blooming daughter was made closer and more intimate than it could ever have been before. It was a simple application of the elementary lever to the problem of lifting the water of the Nile a few feet, so that during the part of the year in which it was not overflowing its banks the rich soil might still be moistened and made fruitful.

Its conception, however, implies a very decided advance toward an understanding of the principles of mechanics. Prehistoric in origin, thousands of examples of it are to be seen on the banks of the Nile to-day, in construction so rude and devoid of "handicraft" that it can hardly have changed since the first model was built. I refer, of course, to the *shadoof*, of which the well-known "well-sweep" of the frontier home is a variety, in form and operation so similar that no description is needed. Every time a shadoof operator lowers his bucket into the Nile he raises a weight several times as great as his own at the short end of the "sweep," and it is easy to see that armed with this principle alone an indefinitely large number of men, properly directed, might do notable things. Another very common water-lifter on the Nile is the *sakkiyeh*, a much more complicated machine, whose invention and use must have had an important bearing on the development of engineering in Egypt. The step from the "shadoof" to the "sakkiyeh" is a long one and is especially important because it means the substitution of the muscles of animals for those of men as a source of power, or at least it makes such substitution possible, when desirable.

It is a curious paradox, but in a general way it is true, that the more complicated a machine is the less intelligence is required to manage it. Illustrations of this fact will suggest themselves to every one. The most delicately organized and most elaborate piece of machinery in general use is the watch, which, in its crudest form, is little less than marvelous in its performance. But no technical skill is necessary to its use and even women (whose inborn dislike for and ignorance of anything like a machine must forever bar them from that participation in political affairs for which some of them are so anxious) get on fairly well with a watch, sometimes winding it with considerable regularity. No ox or buffalo or camel could ever work a simple "shadoof;" but when the intelligence of the operator is put into the machine itself it becomes the "sakkiyeh," a self-filling, self-emptying series of buckets strung upon a loop of rope and kept in motion by the rotation of a wheel about six feet in diameter upon the circumference of which it runs, like the chain of a common "chain pump." This motion in a vertical plane is derived from another about a vertical axis through a pair of "gear-wheels" of about the same dimensions, and the whole is of wood of the roughest and rudest workmanship, so crude in fact that it is difficult to see how the thousands of sakkiyehs seen to-day can be different from the original model.

Mechanically, however, the advance from the shadoof is enormous, for now we have an effective water-lifting device operated by a simple "pull." This "pull" is made continuous by applying it at the end of a pole twelve to eighteen feet long, the other end of which is fastened to the vertical axis of the last gear-wheel, in the well-known fashion of applying "horse-power." An ox or camel (or sometimes the two yoked together) furnishes the "pull," keeping up its "weary round" during long hours and days and, as if to diminish the possibility of its displaying any intelligence in the performance of its task, its eyes are carefully blinded.

Historians who have touched upon the subject are not agreed as to the time when the sakkiyeh began to be used in Egypt. On the one hand it has been held to be an imported device and that its introduction was as late as about 600 B. C.; on the other it is maintained that it was in use as early as the first three or four dynasties of what is called the historic period in Egypt. It seems to me that the latter is far the most probable conclusion. The "wheel" in various applications and uses was known in Egypt in the remotest period. It is figured in many ancient tombs; objects being moved "on wheels" are often pictured, and one of the most interesting things in the recent remarkable "find" of the American archæologist, Mr. Theodore M. Davis (the tomb of the parents of Queen Tii) is an almost perfectly preserved chariot, of light and graceful design, whose wheels, with six slender spokes, might have been made yesterday instead of nearly three thousand five hundred years ago. In the tomb of Menes, the founder of the first dynasty, was found an object that must have been turned in a lathe, and the potter's wheel is prehistoric.

Considering these facts, and also, that in Egypt the problem of water lifting was probably more important than in any other country, it seems reasonable to assume, in the absence of evidence to the contrary, that the sakkiyeh was either invented in Egypt or it was borrowed from some unknown race at a very remote period. If this conclusion be correct, the principle of the "wheel and axle" must have been known to early Egyptian engineers. With the wheel and axle, that is the "capstan or windlass," the lever, the inclined plane and the pulley, almost anything can be accomplished, always assuming a sufficient amount of "pull" available. Did the Egyptians understand the use of the pulley? There is much evidence to show that they did. Commander F. M. Barber published a few years ago an excellent little book on "The Mechanical Triumphs of the Ancient Egyptians," and in it he argues that the "rigging" of the boats used by Queen Hatasoo in her famous expedition to Punt, pictured so beautifully on the walls of her great temple at Thebes, proves that the pulley must have been in use at that time, about 1600 B. C. Indeed, it can hardly be imagined that even at a much earlier period the single pulley, by means of which the direction of a force is so easily changed, was not well known and in common use. As to the "block and tackle," or multiplying pulley, there may be doubt, although there seems to be little evidence of any kind.

Of simple machines for the movement of heavy masses perhaps the most powerful and useful is the screw. The possession of this most valuable device by the engineers of ancient Egypt can only be a matter of inference, as there is as far as I know no direct evidence. In the Delta of the Nile from Cairo to the sea there may be seen to-day scores of "pumps" of that peculiar form known as the "screw of Archimedes." Its invention is generally attributed to that great engineer, but it is by no means certain that he did not find it in Egypt when he came to the famous school at Heliopolis, about 250 B. C. In form and principle it is essentially identical with an ordinary screw, from which it was probably derived.

It seems to me, therefore, that in the simple hydraulic machinery found in Egypt to-day may be found all of the elements necessary to the performance of the great engineering operations of its remote past. That the machines themselves, mostly constructed of wood, have not survived is not strange. With the passing of the Ptolemies the glory of Egypt departed. A partly worked out gigantic obelisk, with two of its faces undetached from the mother rock, lies in the granite quarry at Assouan, a pathetic record of arrested ambition. One day, thousands of years ago, the workmen left it never to return, leaving also, near by, an unfinished colossal statue. Egypt became a Roman province, her day for building great monuments, temples, and tombs was gone, and for two thousand years she has been the prey of other nations. Only those mechanical devices actually essential to the cultivation of her soil have been perpetuated by continued repetition, without improvement in form or material.

The building of the pyramids, and especially the great pyramid at Gizeh, involved, in the opinion of many people, greater difficulties in the way of transportation and "handling" of great masses than any other engineering feat of old Egypt, but it does not seem to me to have been necessary to resort to such extraordinary measures as are suggested by Commander Barber in the volume mentioned above.

His solution of the problem involves the building of a series of inclined planes, increasing in grade and length as the pyramid rose, until at last the two-hundred foot level was reached and perhaps even so far as to make it possible to deliver stone at the summit by this process. It is well known that the moving of large masses on "sledges" was common; that good "ways" were constructed for this purpose; that friction was lessened by the use of oil on the track, as is shown in ancient pictorial representations. Naturally the inclined plane would be much used, but the construction of such a plane as would be required to deliver, by any practical grade, the material of the upper half of the pyramid would demand an almost impossible outlay in labor and time, especially when it is remembered that the plateau upon which the pyramid stands is more than a hundred feet above the river from which the material comes, and that the descent to the river level is very abrupt. Of labor, it may be assumed there was an indefinite supply, but of time there was certainly none too much, according to the well-known account of the building of this pyramid given by Herodotus. The story was an ancient tradition when related to him nearly 2,500 years ago; briefly, it was that 100,000 men were employed for ten years in building the road over which the material was hauled from the Nile; that its length was over 3,000 feet, and its height at its highest point was forty-eight feet; that it was constructed entirely of polished stone, on which characters were engraved. The building of the pyramid itself required twenty years more, and although he undertakes to tell how it was built the only reference to the real difficulty of the work is in the statement that "the stones were raised by machines made of short pieces of wood," and that there were as many machines as ranges of stones, or "steps"—or, there was only one, which was easily carried from one range to the next. He quaintly remarks that he must tell it "both ways as it was related" to him, thus emphasizing the uncertainty of his own account. An inclined plane to carry the material to the middle or to the top of the pyramid would be enormously greater than that described by Herodotus.

Supposing it to have existed, the question of getting rid of it when the pyramid was completed would be a very large one. Everyone remembers the story of the building of the great dome of the Cathedral at Florence and how it was proposed that it be supported during construction by an enormous mound or cave of earth. When it was objected that the cost of the subsequent removal of this would be very great the ingenious device was suggested of mixing with it, as it was dumped in, a large number of small copper coins for the sake of which it was thought the people would gladly remove the entire mass. But King Cheops is reported to have been an exceptionally "wicked and parsimonious" man, and it can hardly be believed that he anticipated the Florentine genius.

However built, it was well built, for here it stands as it stood when finished nearly six thousand years ago, still the most remarkable structure erected by man, only its outer smooth and polished skin having disappeared after millenniums of persistent attack, not only by "time and the elements," but by a race of men whose accomplishments as robbers and destroyers are without parallel.

When the Sphinx, that watched its building from a point only a few hundred feet away, shall speak, we may know exactly how it was done, but not sooner, I fear.

Again, the engineer is at work in Egypt; tall, smoking chimneys arise where once stood the graceful obelisk; instead of beautiful temples, huge and ugly factories are being built; the splash of the river steamboat and roar of the railway train have driven the crocodile from the noble river, the waters of which are being controlled by canals, dams, and "barrages."

The silhouette of the camel train will soon cease to break the horizon line; the shrill cry of the shadoof and the moan of the sakkiyeh will after a while no longer be heard; and with them, alas! will have gone much of the charm of the valley of the Nile. But for ages to come there will be the pyramids and the solemn desert surrounding all.

EXPLOSION OF RADIUM TUBES.—J. Precht reports that a small glass tube with walls 0.5 millimeter thick, containing 25 milligrammes of purest radium bromide, exploded after eleven months' use with a loud report. Three minutes before the explosion it had been removed from a bath of liquid air and placed on a wooden table. It had been used several times before. The force of the explosion was such that the glass was shivered into almost microscopic particles which were strewn all over the room, the radium being seen in the dark like a starry sky. The pressure in the tube must have been at least 20 atmospheres, and was no doubt due to the evolution of gaseous decomposition products of radium.—J. Precht, Physikalische Zeitschrift, January 15, 1906.

FLOWERS THAT FEEL.*

By JOSEPH H. PAINTER.

IN all the wonderful storehouses of Dame Nature there is nothing more remarkable than her success in mimicking one object by another of widely different character, even that of a plant by an animal, as the "dead-leaf butterfly" (*Kallima*) of the East Indies and the "walking-sticks" (*Diapheromera*) of our own woods, and the habit of certain plants of feeding upon animals and of mimicking their actions. For there are five hundred species of the vegetable world which, in one way or another, use animal matter in their struggle for a place among their mates. Some of these have a distinct apparatus by which the plant captures the luckless prey, but others produce a sticky secretion with which the insect becomes covered, and suffocates from the stopping of the breathing pores or starves from inability to obtain food. True, there are many plants which produce mucilage-covered stems, but often for the better protection afforded the flower from creeping visitors when the fertilization is provided for winged insects.

Among this number of so-called "carnivorous plants" is the family *Droseraceae*, the sun-dew family, the most commonly cultivated of which is *Drosera capensis*, a native of South Africa. This plant bears leaves which are elongated, slightly concave along the middle and bluntly pointed. They arise from an almost woody axis, but their greatest peculiarity is the green leaf-like footstalk or petiole below the gland-bearing blade. This blade extends from one-third to one-half the length of the entire leaf, and is covered with numerous tentacles. These project from the upper surfaces and margins, and are of unequal sizes, those on the margins being the longest. Each is tipped with a round gland, which secretes a sticky sweetened substance—the bait for the unfortunate insect. This secretion is clear and thick, and may easily be drawn out into threads. It shines in the sunlight as dew drops, hence the common name "sun-dew." If an insect alights upon the tentacle-covered blade, those tentacles nearest begin to draw together over the intruder, which struggles to free itself, each attempt only adding more and more to its already covered body until the breathing pores are closed up, and the tentacles close over it in their fatal grasp. Gradually those nearest draw together, then those farther away, until the whole leaf folds over the luckless prey. With some species of the genus this occurs in the remarkably short time of ten minutes. The moment one of the sensitive tentacles has been subjected to an irritation of some nitrogenous substance, as insects or a piece of meat (for the plants have the astounding faculty of discriminating against mineral substances) the secretion of the gland proceeds more rapidly. Besides an acid juice, as well as a ferment, is added to the sticky fluid to aid in the breaking down of the animal tissue, in order that the plant may absorb the nutritious portions. The action of these juices upon albuminous compounds is very similar to that of pepsin. It is only when the prey is very large that the leaf becomes hollowed in the middle, and more tentacles are brought to bear upon it. But if the creature is small, as a mite, the process is complete in two or three days, and the leaf reassumes its open position with the tentacles again straightened, so that the hard and dry portions of the insect are left upon the surface to be blown away by the first breeze that springs up. After an interval of rest lasting a couple of days the glands again secrete the sticky bait, and the leaf is ready for another meal.

The pitcher plants of the family *Sarraceniaceæ* are relatives of these insect-catching *Droseras*, for both families belong to the same order (*Sarraceniales*). These plants, too, capture insects, but they do so without the exhibition of any movement of themselves. Their leaves are variously shaped into hollow receptacles resembling trumpets, funnels, or pitchers. They are all natives of America: *Sarracenia*, containing about eight species, being found from Labrador to Florida, *Chrysamphora* (or *Darlingtonia*) with one species, in California, and *Heliamphora*, also with one species, in Venezuela.

DROSERA CAPENSIS, SOUTH AFRICA.

Of these various forms, the commonest and the one of widest range is the side-saddle flower or pitcher plant (*Sarracenia purpurea*). This is an inhabitant of bogs and marshes often associated with *Droseræ* and other insect-catching plants. The leaves are in rosettes resting their bases on the damp earth, and thence curve upward. They are inflated like bladders, closed at the base, and with a hooded orifice at the top. Along the inner side extends a fin-like wing, which is marked with green and purple veining. This wing performs the true functions of the leaf, while the inflated portion is the trap set for insects.

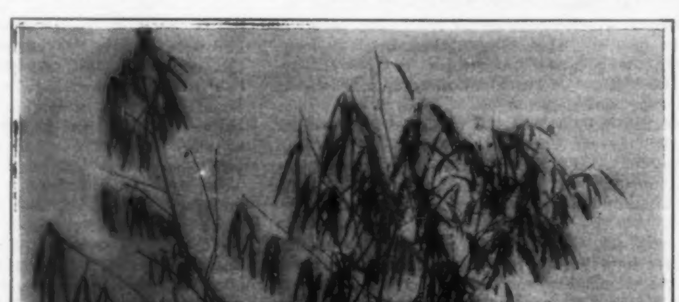
The edge of the opening into the cup or pitcher opposite the hood bears a row of shell-like projections, which protrude into the cup and form a decided obstacle to the exit of any insect that is unfortunate enough to attempt to climb over it. Beneath and within this rim and over the inner surface of the hood are stiff downward-pointing bristles, among which are honey-producing glandular hairs, so that the parts about the aperture are coated with a thin film of sweet juice—the bait. Insects both with wings and without are attracted by this honey, which is more plentiful farther within and away from the rim of the cup. They get deeper and deeper into it, and then are unable to retrace their steps. Every attempt to climb up again is impossible, because of the presence of the bristles. Below the row or band of these bristles the inside lining of the walls is covered with smooth, slippery decurved cells, and these hinder still more the intruder in his efforts to escape. He slips on and on, and is drowned in the water with which the cup is partly filled. This water is obtained by the hood which, acting as a sort of funnel, catches the drops of rain and directs their flow into the cups. Whether this liquor filling the bottom of the pitchers is simply rain water mixed with the decaying bodies, or whether it is, in part, a secretion of the plant itself, is a matter still to be ascertained. It is sometimes clogged with the putrefying victims, so great is their number. When these captured animals are undergoing decomposition in the pitfalls, the liquid becomes brown in color, and often gives off an offensive odor.

Yet within this same genus there is a great diversity in the apparatus adapted to the capture of prey. In the "trumpet-leaves" (*Sarracenia rubra* and *S. drummondii*) of our Southern States the liquid contained within the tube-like leaves has an acid reaction, and is secreted by the cells in the interior of the cavity itself. Because of the presence of the hood, which in these plants becomes a sort of lid, the orifice is closed to the entrance of rain drops, but is not a hindrance to the entrance of insects into the pitfall. The rim around the aperture is turned back upon itself, and serves as a small platform upon which the insect alights from its flight, for because of the erect habit of these leaves, insects depending upon their feet alone for access have an almost impossible climb, and nothing to attract them to the position of the honey. About the mouth of the trumpet and on the under side of the lid are honey-secreting glands, which pour out their sweets in such abundance that it may often be seen as drops on the margin of the aperture and hanging from the lid. Serving as an attraction to the honey is the great variety and contrasting brightness of the colors of the trumpet. The veining is more prominent and often strikingly colored, and the upper half of the leaf is of a different shade from the lower part, being much lighter green and sometimes almost white. The visitor, attracted by the bright colors, finds and feeds upon the honey, and crawls over the edge into the interior. Here is the beginning of his troubles, for he is upon a dangerous footing. Among the honey-bearing cells are innumerable others which are smooth and conical, with the solid apices directed toward the base of the pitfall. Every attempt to withdraw only becomes an aid to destruction, for with each movement the honey seekers sink farther and farther toward the bottom of the pitcher, where they are drowned and ultimately entirely decomposed.

The "yellow-flowered trumpets" (*S. flava*) have an open lid, and do not secrete their own liquid, for rain can and does enter through the aperture. Otherwise they obtain their nitrogenous food as do the other trumpets already described.

Still farther specialized are the "monkey cups" (*Nepenthes*), in which the leaves are of three distinct parts. These natives of the tropical East bear their foliage just as ordinary plants, but strange as it is the mid-vein is prolonged beyond the blade of the leaf, and stranger still, this mid-vein bears at its tip a cup or pitcher often closely resembling the cups and pitchers of the *Sarracenias*. In most of the species of the genus the mature pitchers are from four to six inches in length and one inch in diameter, but one from Borneo (*N. rajah*) has a cup the height of which reaches twenty inches and has an orifice four inches in diameter, while below the orifice the pitcher

TRUMPETS. SARRACENIA FLAVA. SOUTHEASTERN UNITED STATES. FAMILY SARRACENIACEAE.



A MIMOSA OF ARGENTINE.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

expands to six inches. It is so large that a pigeon would be completely hidden within it. These pitchers, when immature, are mostly closed by the lid and of dull colors, but after maturity the lid opens and the pitcher becomes gayly colored. This makes them very conspicuous in their native densely-shaded forests. About the rims of the pitchers and on the under surface of the lid there is a secretion of sweets. This honey is often so plentiful that it may be seen glistening upon and even dripping from the fluted turned-over margins of the pitchers. Animals that suck honey from the lips of these cups wander inside, where the face of the cup is smooth and steep or even receding, and, too, it is covered with a slippery wax, which causes the invaders to slide down into the water with which the cups are partly filled. In large pitchers the egress is made even more improbable by the presence of sharp teeth upon the inside of the rim of the aperture. Most of the creatures that fall into the water are speedily drowned in the liquid. This is mainly rain-water but, as Dr. Hooker has shown, upon the presence of animal matter in the fluid the glands on the inner surface at the base of the pitcher add a secretion of a series of acids mixed with an organic compound resembling pepsin. From experiments it has been shown that these fluids act upon animal tissue in a way not only similar to digestion, but so nearly that process, it may be properly spoken of as digestion. The portions of the bodies of victims of *Nepenthes* which is acted upon by these fluids is afterward absorbed by special cells at the bottom and on the lining walls of the lower parts of the cups.

In all these plants the use to the plant is the obtaining of nitrogenous foods, of which they are deprived by the character of the soil in which they grow. But Dame Nature has still another series of interesting and astounding surprises for us in the plant world. There are many plants for which, instead of providing food in a wonderful way, she provides protection, both from falling raindrops, which would tear the delicate leaves, and from excessive evaporation, which would rob them of their moisture and cause their drying and final death. The most wonderful of these are the so-called sensitive plants or *Mimosas*, the commonest of which is *Mimosa pudica*, the true sensitive plant or humble plant of the gardens.

The leaves of this wonderful plant are doubly compound, there being two pairs of branches of the petiole or leaf-stalk, each branch bearing numerous leaflets arranged closely together, the outer leaflet overhanging the next when the leaves are fully expanded to the action of the air and light. These leaves show an immediate response to the action of a stimulant, being irritable in a very high degree, and answering to a shock so light as the shaking caused by one's steps past the table upon which the plant may be growing.

Upon pinching or otherwise applying a stimulant to one of the leaflets, the opposite leaflet to that upon which the stimulus acted will at once exhibit an irritation and will rise, almost simultaneously followed by the nearest neighboring leaflets in strict sequence as far as the base of the small leaf-stalk; then a pause will be noticed, but it will be immediately followed by the rising of the next lowest pair of leaflets on the other petiolules, and the movement will extend itself regularly toward the tips of the leaf. At the same time these petiolules draw toward each other somewhat like the closing of the outstretched fingers of the hand. Next the primary leafstalk droops, carrying with it the hanging leaflets. And, within a short space of time, the leaves next the one which has responded will exhibit the irritation, but acting in the reverse way—the petiole falling first, the petiolules next, and the leaflets folding last. All the leaves of a stalk of *Mimosa* may be thus set in motion, even though the stimulus has been applied to a single leaflet. This exhibition will last for varying lengths of time, depending, of course, upon the intensity of the force with which the plant was set moving. Finally, however, the petioles will resume their erect position, the petiolules will expand, and the leaflets will spread themselves out to the action of the light.

The benefits derived from this curious habit are many. The heavy drenching rains of their native tropics would tear the delicate leaflets, but at the touch of the first drop this is rendered impossible. It also happens that dry, dusty winds and driving sand

NEPENTHES. A HYBRID WITH NEPENTHES' HOOKERIANA.

and extraordinary noontime heat cause the folding of the leaflets. The leaflets escape the various dangers by this assumption of the "sleep movements"—in the clear night, the loss of water by radiation toward the sky; in the hot mid-day, drying up in consequence of rapid evaporation; in rainy weather, the breaking of the tender leaves and their inclination toward the ground, as well as the collapse of the whole plant under the weight of the falling drops.

ON THE RIGHT A PITCHER PLANT OF EASTERN NORTH AMERICA. ON THE LEFT A RED-FLOWERED TRUMPET LEAF SARRACENIA RUBRA OF SOUTHEASTERN UNITED STATES.

WHY THE EYES OF THE CHINESE SEEM TO BE OBLIQUE.

CONTRARY to the general opinion, the eyes of the yellow people are not oblique, notwithstanding the fact that they appear to be. In these people the line joining the commissures of the eyelids divides the eye into two equal parts, and is exactly at right angles with the axis of the nose. If it is not always so, the exception is much less frequent than in the whites, for, as a general rule, it is in the latter that the eyes are not at right angles with the nose. If our eyes seem to be so, it is due to habitude, and if those of the Chinese appear to be oblique, it is due to an optical illusion.

In order to convince ourselves of the influence of habitude, it will suffice to look at a well known face in a mirror by reflection, or, while shaving, for example, to regard one's self by double reflection in two parallel mirrors. As what is ordinarily seen to the right is observed to the left, and *vice versa*, unsuspected distortions and asymmetries suddenly appear. The effect, moreover, is exaggerated and, in a manner, doubled, since a line making an angle a with the horizontal, and taken for it, is afterward seen in a position making an angle $2a$ with its initial position. It is for the same reason that we rarely recognize ourselves in a full face portrait, while those to whom our face is familiar find it a very good likeness. The photographer endeavors to counteract this bad effect by never taking a full face view of his sitter, and by turning the latter's head in such a way as partially to correct, by the perspective, the asymmetry of the features. In this, however, he does not always succeed. The most eminent sinologists, Von Siebold, Abelsdorff, and Schlegel, are of the opinion that the eyes of the yellow people are straight. To be convinced of this, it is only necessary to examine one of their portraits, or, what is better, the original. If the eye appears to be oblique, it is due to the fact that the upper eyelid and the general direction of the eyebrow are oblique. The upper eyelid on the side toward the nose forms a special fold which causes it to cover entirely the angle in which the lachrymal gland is situated. The eyelids are generally thinner and the eye less open.

The head of the Japanese presents another curious peculiarity, from the fact that the lower lobe of the ear is almost totally lacking. This is not a real anomaly, however, for it is we who have a badly formed ear, or at least one different from that which nature would have given us if we had allowed her to act alone. Our ear has become deformed for the reason that for centuries our ancestors suspended therefrom more or less odd and heavy ornaments which progressively elongated the lower part of it. We have inherited both the custom and its effects, the lobe. A fact which well proves the absence of this useless and cruel custom among the yellow folk are the terms "earring" (*mimi-gaué*) and "ear-lobe" (*mimi-tabu*), neither of which was introduced into the Japanese language until the epoch at which the Japanese entered into relations with the people of the West, whom they styled barbarians.—Translated from La Nature for the SCIENTIFIC AMERICAN SUPPLEMENT.

THE PLACE OF CEREAL BREAKFAST FOODS IN THE DIET.*

IT has been estimated that a man at moderate work requires about a fifth of a pound of protein and about 3,000 calories of energy per day. As a general rule, the protein is in considerable measure supplied by meat, fish, milk, and other animal foods, which also supply the bulk of the fats. The carbohydrates, which are lacking in animal foods, are abundantly supplied by the vegetable foods, which also provide some protein and a little fat. Fresh fruits and vegetables supply acids and other bodies which are believed to have a distinct value as stimulants to the appetite and in other ways. The mineral matters needed in a well-balanced diet occur in small but sufficient quantities in almost all classes of food materials. In a mixed diet the energy-producing carbohydrates are more important ingredients of the vegetable foods than protein, which will be supplied by animal foods. Of course, if for any reason the animal foods are omitted from the diet, the importance of protein and fats in the vegetable foods increases greatly. In such cases the legumes and cereals, which contain more protein than the vegetables and fruits, take a very important position in the menu.

The most important use of cereals is undoubtedly as breadstuffs. Bread has thoroughly established its place as the most palatable, nutritious, and convenient cereal preparation for general use. Crackers or biscuit and the various kinds of cake, pastry, etc., are in a way varieties of bread or substitutes for it and are recognized as staple foods. What place, then, is left for the so-called breakfast foods?

At dinner, aside from bread and sweets, carbohydrates are supplied in the vegetables served with the meat. In the morning and sometimes also at luncheon or supper these do not seem so attractive or convenient and in their place we use some preparation of cereals. There are reasons for believing that there is a growing tendency in this country to use less meat at all meals, perhaps, excepting dinner. This, of course, increases the importance of cereal foods as part of the diet.

Some of the prepared cereal foods are pressed into cakes or in some other way manufactured into such forms that they may be eaten to a greater or less extent like bread or crackers as an accompaniment to various dishes. Such preparations are undoubtedly wholesome and nutritious, but except for their flavor and texture, which may appeal to many, they do not surpass the ordinary breads, which experiments have shown have as great or greater nutritive value and usually cost less. Cereal breakfast foods of different kinds are used to a greater or less extent in the preparation of made dishes. Thus, a spiced steamed pudding may be made from oatmeal, and very palatable little cakes can be made from some of the dry flaked cereals. Fried hominy and fried corn-meal mush are standard foods sometimes served with fried chicken and some other dishes, and boiled rice is a common substitute for potatoes or other starchy foods. The manufacturers of certain classes of goods have taken great pains to devise recipes for their use in making desserts and as ingredients of other dishes. The amount

* Abstracted from Farmers' Bulletin 249, issued by the United States Department of Agriculture.

of these cereal foods used in this and other similar ways is probably large, but the bulk of the total output of the mills and manufactories is used to provide a special breakfast dish.

In the diet of young children cereal foods are of much value. The cereal breakfast foods, when they agree with the children, are wholesome and reasonably economical articles. When eaten, as is usually the case, with milk or cream, they are an important addition to the diet. The ill effects sometimes noted may usually be avoided if excessive amounts of sugar are not added. Dates or figs, which are sometimes cooked with cereals, not only are palatable and wholesome, but also offer an easy way of varying the cereal dish.

Cereal breakfast foods of different sorts are also valuable foods for the aged, as when properly cooked they are soft and easily taken care of in the digestive tract. They are often preferred to more hearty foods, and their use is certainly rational. In institution dietetics, especially when a considerable number of the inmates are children or aged persons, some breakfast cereal should find a place in the menu, and is not inconsistent with economy.

In invalid dietetics cereal foods are, of course, almost indispensable, and the standard flours and meals and the more modern prepared breakfast and special cereal foods all find their place, either when cooked in ordinary ways or for the preparation of gruels or other special dishes.

THE CHEMISTRY OF ARTISTS' COLORS IN RELATION TO THEIR COMPOSITION AND PERMANENCY.*

By JOHN M. THOMSON, LL.D., F.R.S.

THE circumstances which chiefly influence the changes in pigment substances may be briefly enumerated under the following heads: Action of light; action of heat as seen in volatilization; molecular rearrangement in the substance itself; processes of oxidation and reduction; action of noxious gases as alkaline and acid vapors, sulphuration, etc.; action of solution, this latter being somewhat rare. The effect of the physical condition of the pigment should also be mentioned, as the color and permanency differ considerably in pigments according to their state of aggregation.

For the purposes of examining the general effects of these various conditions, I propose to group the colors in the following divisions, viz.: Whites, reds, yellows, greens, blues, browns; and it must be remembered that the colors must be submitted to more severe tests than those probably existing under natural conditions.

It is difficult to illustrate quickly the action of light on pigment substances, although the deleterious effects after long exposure are well known, especially in connection with some organic coloring matters. By placing, however, a sheet of paper colored pink by one of these colors and covering a portion of it with a dark screen, in a few minutes the portion left free by the star which has been cut in the screen has faded in a very marked degree to a pale, almost colorless, yellow. Not only do we find a fading of color under the influence of light, but changes are also produced in which an actual change to a different color takes place. A yellow wash is not an organic color, but mineral, a compound of tungsten. On holding it in the beam for a few minutes behind the screen the portion where the light has acted has changed from the pale yellow to a blue-gray color. Of course both these colors have been subjected to conditions vastly more severe than what could happen in ordinary circumstances; but if we take the length of time colors in pictures may be exposed to sunshine and bright light, these conditions become comparable. In connection with the action of light on colors, the most important observations on this point are the experiments of Dr. Russell and Sir William Abney, detailed in their report to the Science and Art Department in 1888. Experiments have also been carried out by Prof. O. N. Rood, Mr. W. Simpson, and Prof. W. N. Hartley (British Association Reports, 1886).

The changes produced by heat on colors, as might be expected, are more patent than those produced by light. They may be divided into two classes—(*a*) those which are purely intermolecular change within the pigment without change of composition; and (*b*) those in which a distinct alteration in the composition takes place. As an illustration of the first case, we may take the action of heat on iodine scarlet (HgI_2) a deep red color, which on heating you see partially volatilizes, the remainder on the sheet of paper becoming converted into a yellow variety. This variety is, however, so far as chemical analysis can tell, of the same composition as the original red compound. On allowing the red variety to cool and then rubbing it with some hard substance, it passes back again into the red variety by mere friction. Another instance of change of color without change of composition may be seen in ordinary vermilion (HgS). When this substance is obtained by precipitation it is black, when a solution of ammonium polysulphide is added to a solution of the mercury salt; but on boiling the black precipitate at first formed, it is gradually transformed into the brilliant red variety.

The cases of change of color on heating with change of composition are much more numerous. These changes depend more particularly, either on the total decomposition of the pigment into its constituents, as may be seen in the decomposition of Scheele's green, which is entirely decomposed into arsenious acid and metallic copper; or the conversion of one compound into another containing the same constituents, but differently arranged, as in cobalt compound, which changes from red into a blue compound; or by the dehydration or loss of water from the pigment, as in the case of the darkening of ochers, etc.

Passing now to the various groups of pigments, I think the first and most important groups are the whites. These colors occupy this position from the fact that one of the most important of the group is white lead, which is not only employed itself as a white color, but is also used to large extent in mixture with other colors, from the property which lead compounds particularly possess of saponifying with the vehicles with which pigments are generally mixed. Such lead pigments are especially acted on by sulphur vapors with the formation of black lead sulphide. This property of lead compounds saponifying with the oil and forming a compound with it (linoleate of lead), although making the pigment work easily with the brush, may also exercise an effect in destroying the protective action of the oil as a coating, and so rendering the new compound formed more susceptible to the action of the sulphur vapors. In the case of white lead itself, it seems after a time to exercise some especial drying or hardening effect on the oil. This darkening action of sulphur vapors on lead compounds renders them dangerous when mixed with other colors containing sulphur, more especially when the mixture, probably stable at first, comes into contact with vapors capable of acting on the color with which the lead compound has been mixed. A mixture of white lead and another color containing sulphur remains permanent, but bring in contact with them a wash of an alkaline substance, and action is at once set up, and a darkening of the pigment takes place. It is fortunate that this darkening of the lead pigments may be counteracted to a certain extent by the process of oxidation, the lead sulphide being converted into the sulphate by strong oxidizing agents.

The permanent whites in regard to sulphuration are barium sulphate and oxide of zinc—the first because it is an extremely insoluble substance, withstanding the action of acids; the second, because it forms a white sulphide. Oxide of zinc, however, although undeteriorated by sulphur compounds and alkaline gases, is acted on by acid vapors.

There is another white, a compound of barium—barium tungstate—which is of a distinctly permanent and fairly brilliant character, but may perhaps suffer the same objection to all whites, except the lead whites, namely, that it does not possess enough "body." I think however, that it is a white pigment deserving more attention from artists than it has hitherto received.

As the principal white pigment still used by artists is derived from lead and the best white obtained from it the basic carbonate, $2(PbCO_3), (PbOH)_2$, it may be of interest to note the different classes of carbonates to be met with, and their probable effect on other pigments and oils or vehicles. Carbonates are divided into the three classes, normal, basic, and acid. A normal carbonate is one in which the metallic oxide or base exactly corresponds to or neutralizes the acid with which it is combined; a basic carbonate contains an excess of the base, and an acid carbonate a corresponding excess of the acid ingredient. Now, as both free alkalies and acids act on the materials used as vehicles in painting, it is evident that an alkaline carbonate may commence a chemical action proving injurious to the painting; and conversely an acid carbonate may also initiate a change by the excess of acid in it combining with the free base in the alkaline carbonate. A second action to be kept in mind is, that many of the oils themselves become acid by exposure to the air, and the free acid so produced tending to combine with any free base existing in a pigment will naturally set up chemical action of an injurious kind. There is not space to go into further chemical actions set up by changes in oils and other vehicles, but from the little I have been able to show you it is evident that for stability in a color the more neutral or normal the pigment can be in its composition the better.

On turning to the red pigments we find that with the exception of those of organic origin, iodine scarlet and those containing lead, they may be regarded as practically stable substances. This arises from the fact that some good red colors can be obtained from the group of natural oxides of iron, of which Indian and Venetian red (Fe_2O_3) may be taken as types. These do not yield to sulphuration, although they might show signs of failing under the influence of acid vapors. Under ordinary conditions properly prepared vermilion (HgS) ought to have fair permanency. Being a sulphide, it undergoes no change itself, and exhibits considerable resistance to chemical action. It has, however, a peculiar tendency after a time to become dull in color, and therefore to change and lose tone considerably when in thin washes. This change is probably due to the return of the red variety of the pigment to the black or non-crystalline variety, a transference which I have already noticed at the commencement of my paper. Lead pigments should be avoided in mixing other colors with vermilion. From the expensive nature of good vermilion there is much temptation to adulterate with an inferior substance, antimony vermilion (Sb_2S_3), which, as you see in the experiment before you, can be readily obtained by boiling together antimony terchloride with a solution of sodium hyposulphite. Another danger in vermilion is when it contains free sulphur, an accident which may readily happen from the method of its preparation.

The other red pigments which must be regarded as of dubious permanency are, as you would expect, the lead colors, notably red lead. This substance is rapidly acted on by acid vapors, notably nitric acid, which at once turns it to a brown color. Red lead itself is probably formed by the union of two other oxides of lead; by the action of the acid, as you see in the experiment before you, one of these oxides can be removed by an acid, leaving the other as a brown compound, the original brilliancy of the red having gone. Being a lead compound, it is also acted on by sulphur vapors, and cannot be regarded as a proper color for the palette, however useful it may be for coarse outside work. Red orpiment or realgar (As_2S_2) must be regarded as a dangerous substance to use, as it destroys other colors.

With regard to the group of yellow colors, it is unfortunate that so many of the most brilliant of them and of the oranges are derived from lead compounds, and so are subject to the same criticism as the whites in relation to sulphuration. Yellow and orange chromes being lead chromes are at once blackened and destroyed by a brush of sulphur compound. It is true that for light chromes the strontium and barium chromates can be used. These are unchanged, so far as sulphuration is concerned; but the chromium compounds are unfortunately subject to changes produced by other gases, notably those producing reducing actions. In chromium compounds the metal may exist in a higher or in a lower state of oxidation, producing in each case compounds of different colors; in the lower or chromous condition these are green or almost colorless, in the higher or chromic condition, yellow and orange, sometimes passing to red. On brushing, therefore, one of these yellow washes made from a chromic compound, with sulphurous acid, you see it changes at once to the lower compound, giving a green color. This susceptibility to reduction explains the changes they undergo when in contact with other colors of organic origin. They also change under the influence of alkalies.

Undoubtedly under many conditions one of the most permanent of yellow colors is pure cadmium yellow (CdS). This substance is not acted upon by sulphuration or affected by the action of weak alkalies or acids, and it may be mixed with other pure colors, such as pure ultramarine. Permanent, however, as we might suppose this color, it is dangerous to mix with blue copper pigments, as chemical action seems to be set up and a blacking action to be produced. This may be seen in a mixture of a copper blue with cadmium sulphide, which at once blackens when the sheet is blown upon by these acid vapors. In thin washes cadmium yellow is also subject to change into the less colored sulphate by oxidation. Of the yellow colors, the most permanent, like the reds, are to be found in the ochers or earths. The yellows differ from the red ochers merely in being hydrated oxides, their lighter color depending on their state of hydration or their dilution with pure white clay. On heating they become darker in color, and, being hydrated oxides, they are liable to be acted on by acid vapors, but otherwise may be regarded as durable colors under normal conditions. The least permanent of the common yellow pigments are the lakes, king's yellow, and zinc chromate.

The green colors used as pigments are derived chiefly from compounds of copper and chromium. Of these the chromium compounds, except perhaps in the case of pure malachite, must be regarded as probably the most durable. The copper-greens are subject to rapid change by sulphuration, becoming darkened under its action, and they are also liable to change under the influence of gaseous alkalies, becoming of a blue shade.

One of the more prominent greens, apart from chromium greens, which must be regarded as the most permanent, is terre verte, a natural mineral containing iron. Such compounds, although stable under ordinary conditions, are liable to change in color from the conversion of the iron from the lower or "ferrous" into the higher or "ferric" condition.

The green pigments formed by mixtures of the oxides of cobalt and zinc (Rimmann's green) fixed at high temperatures must be regarded as permanent colors.

The blue pigments in common use by artists are to be found in the groups of colors yielded by the compounds of cobalt, the natural ultramarine or *lapis lazuli*, the iron compounds of cyanogen, and in organic colors as indigo. Of these the cobalt blues, known as smalts, are distinctly the most permanent, as they are artificial silicates or glasses in a finely ground condition, and from their insolubility little likely to be acted upon under ordinary circumstances. They are certainly immune to the action of sulphur compounds, but being silicates free from calcium salts they are likely to be acted upon by acids. Mechanical division also produces a change in color in the smalts. In natural ultramarine we have a pigment which may be regarded as permanent unless brought in contact with acid vapors, even weak vegetable acids exercising a very marked effect upon it.

Of the Prussian blues there are at least three different modifications—one a soluble variety, the second an insoluble variety, and the third variety closely allied to the first, termed Turnbull's or Gmelin's blue. The one employed by artists is the insoluble variety. Generally speaking, the insoluble variety may be regarded as a fairly good color, the principal deteriorating agent being alkaline vapors which decompose the color, leaving a dirty brown, due to the formation of oxides of iron produced by the breaking up of the double cyanide. This change may be produced by lime

* Journal of the Society of Arts.

and even the weakest alkalies. The color therefore cannot be used for fresco painting where it would come in contact with plaster. Thin washes of the color are also deteriorated by light, becoming converted into faded brown, but if the exposure has not been of long duration a return to the original blue color may be produced by placing the faded color in the dark for some time. That pigments such as the various forms of Prussian blue should be risky to use as colors may be seen by one or two experiments in connection with the formation of these double cyanides, which depend on the differing nature of the iron salts employed. If we bring together the yellow prussiate of potash with a salt of iron in what I have already described as the "ferric condition," we obtain a precipitate of the true dark blue color; but use a second iron salt which is in the "ferrous" condition, and the precipitate is by no means homogeneous; is of a mixed light blue color, and has a marked tendency to pass into a dark blue under exposure to the air.

Although I had not the intention of dealing in detail with organic colors, there is one so well known as a blue color—indigo—that I should like to say a word concerning it. This color is now obtained in two modifications, the natural and the artificial varieties. It is a deep blue of good body, and a very powerful and transparent color. Although possessing apparently such a strong blue color, the pigment is not strictly permanent. In thin washes it is fugitive, especially when mixed with white lead, and it is markedly acted on by oxidizing agents either direct or indirect. Taking this wash, which you see is of considerable intensity, I brush over it an oxidizing agent, and at once it changes to a pale yellow tint, and if I use more of the oxidizing body you see that the color entirely disappears. It is also acted upon by reducing agents, being converted into a colorless body, white indigo. This substance, however, by mere exposure to air, rapidly returns to the blue color.

With regard to the brown pigments in general use, more especially the mineral browns, they may be regarded as permanent colors. They are composed for the most part of natural earths or natural minerals, containing the metals manganese, iron, or cobalt, and are, therefore, little acted on by light or sulphur vapors. As they are oxides, the most important chemical change in regard to them is that of reduction, which is especially seen in the case of the manganese brown. This color should also be used with caution in connection with vegetable and animal lakes. Burnt sienna and the umbers being oxides of iron of varying composition may all be regarded as permanent browns, except that they also undergo partial change on reduction, although perhaps not to so marked an extent as in the manganese compounds.

Except in the case of one or two special pigments such as indigo, and carthamine red from the safflower, which may be regarded more as a dye than a pigment, the most of the organic colors are used in the form of lakes. The lakes are generally formed by precipitating the coloring matter by means of some oxide, generally those of tin or aluminium. This being done by the action of an alkaline body, the changes such coloring matters readily undergo are seen even in their preparation, as the quantity of free alkali present produces considerable variety in the shade of color. The lakes vary greatly in durability, and of them perhaps the madder bodies may be regarded as the most durable. Those derived from such colors as the logwood extracts have little permanence. When aluminium salts are used for the formation of the lake, the oxide of that metal being unacted on by hydrogen sulphide renders the lake slightly more permanent; that is, apart from any action which might take place in the color itself. Lakes formed with the oxides of tin or of lead are easily destroyed by that gas, and quickly lose their brilliancy of color. Very marked changes are also produced on these organic colors by alkaline and acid vapors. I have here a wash of one of the red lakes and you see that even very dilute quantities of ammonia and of hydrochloric acid gases blown upon the paper at once show most marked changes in the color. The general result of such changes is to produce with alkaline vapors a darker, and with acid vapors a lighter color, but the changes are very various and by no means regular.

There is one group of organic colors derived from coal tar which are quite inadmissible as artists' pigments. It might therefore be imagined that there was no necessity to mention them here; but the brilliancy and tinctorial power that some of these colors possess might tempt some to make artificial pigments, by mixing these brilliant dyes with colorless mineral substances, such as silica, alumina, chalk, or barium sulphates—in fact, to make with them pigments somewhat akin to lakes. Most of these colors are affected both by acid and alkaline vapors, in a manner similar to that which we have seen in the lake colors.

In drawing conclusions with regard to the general behavior of pigments under the various actions which I enumerated at the commencement of my paper, I have arranged the different common pigments in the following table according to their chemical relationships, but keeping in each group the arrangement of colors I have adopted throughout my paper.

TABLE I.—CLASSIFICATION OF SOME MORE COMMON PIGMENTS ACCORDING TO THEIR CHEMICAL RELATIONSHIPS.

(a) Elements.	
Gold.	Silver.
Black.	
Graphite. Ivory black.	Lamp black.
(b) Oxides.	
White.	
Zinc white	ZnO.
Red.	Chiefly Fe_2O_3.
Burnt sienna. Indian red.	Venetian red.
Green.	
Chromium green	Cr_2O_3.
Cobalt green	CoO, x Zno.
Blue.	
Cobalt blue	CoO, x Al_2O_3.
Cœrulean	CoO, x SnO_2.
Brown.	
Burnt umber	Fe_2O_3, MnO_2.
(c) Hydrates.	
Yellow.	
Yellow ocher	Fe_2O_3 x H_2O.
Raw Sienna	Mixed hydrated oxides of Fe and Mm
Raw umber	Mixed hydrated oxides of Fe and Mm
Green.	
Viridian	$Cr_2O_3 2H_2O$.
(d) Sulphides.	
Yellow.	
Vermilion	HgS.
Cadmium yellow	Cd.S.
King's yellow	As_2S_3.
Blue.	
Ultramarines	Mixtures of Si, Al, Na, O and S.
(e) Carbonates.	
White.	
Flake white	$2PbCO_3$, $Pb(OH)_2$.
Whitening	$CaCO_3$.
Green.	
Malachite	$CuCO_3$, $Cu(OH)_2$.
Blue.	
Chessylite	$2CuCo_3$, $Cu(OH)_2$.
(f) Silicates.	
Green.	
Terre verte	Silicate of Fe, Mg, and K.
Blue.	
Smalt	Silicate of Co and K.
(g) Chromates.	
Red.	
Chrome red	$PbCrO_4$, PbO.
Yellow.	
Baryta yellow	$BaCrO_4$.
Chrome yellow	$PbCrO_4$.
Strontia yellow	$SrCrO_4$.
Zinc chromate	$ZnCrO_4$.
(h) Non-classified Inorganic Pigments.	
White.	
Baryta white	$BaSO_4$.
Tungstate white	$BaWO_4$.
Yellow.	
Aureolin	$Co_2K_6(NO_2)_{12}$, $2H_2O$.
Naples yellow	Pb.Sb.O.
(i) Some Organic Pigment Substances.	
Red.	
Carmines	Cochineal beetle.
Crimson lakes	Cochineal beetle.
Madder reds	Alizarin... $C_{14}H_8O_4$. Purpurin.. $C_{14}H_8O_5$.
Yellow.	
Indian yellow	Magnesium euxanthate. $C_{19}H_{16}M_gO_{11}$, $5H_2O$.
Yellow lake	Quercitin.
Madder yellow.	
Green.	
Sap green.	
Blue.	
Indigo	Blue. $C_{16}H_{10}N_2O_2$. iii. iv.
Prussian blue	$Fe_4(FeC_6N_6)_3$.
Sepia	Cuttle fish.

Taking such an arrangement we find the following general points: In group (*a*) the black pigments mentioned are permanent, and one of the elementary metals, namely, gold, is little liable to chemical action. The element silver is, however, readily acted on by sulphur compounds, and drawings with this metal are often altered in hue.

Group (*b*) contains the oxides. These are generally stable bodies not acted on by air, moisture, or hydrogen sulphide, unless they contain metals yielding black sulphides. Such oxides, however, do not appear in the group. The chief danger with this group is from reducing agents. They may also be regarded as practically inert when mixed with other pigments.

The hydrates (*c*), as they contain water, may change in tone by the loss of that substance, and as they have not been prepared at the high temperatures to which the oxides have been subjected, they cannot be regarded as in quite so stable a condition. They are, however, safe colors for all ordinary purposes.

The sulphides group (*d*), as we have seen, are dangerous, especially in mixtures with other colors, often giving up their sulphur and deteriorating the other pigment. Some of them also undergo a change of color by intermolecular change within themselves. They are also liable to oxidizing actions, being gradually converted into sulphates. There is also the danger that in the preparation of some of these sulphides free sulphur may exist, which acts more readily and directly on other colors mixed with them.

The carbonates group (*e*), of which instances are given, if they change at all, do so chiefly by the formation of black sulphides in the cases where the pigments contain the metals lead and copper.

The silicates group (*f*) are very strong pigments, and are little liable to change when derived from natural sources. Artificially made silicates used as pigments might undergo a little solution in water, as they are not of the harder variety of silicates like calcium silicates, but any action of this kind is likely to be very slight. If properly prepared, silicates might prove very lurable pigments, and I have always been surprised that more experiments have not been made with regard to the manufacture of pigment substances in the form of silicates.

The chromates group (*g*) are substances in a fairly high state of oxidation so that they will be acted on most readily by reducing agents, varying the color from the brilliant yellows and oranges to a green hue, due to the formation of lower compounds of chromium.

The manufacture of pigments has become a trade, and I fear in some cases made-up pigments are sold when the pure substance is not insisted upon by the purchaser. Pure pigments can be obtained, but if the artist is so careless as not to satisfy himself that the article he wants is perfectly pure the supply of the faked substance will continue. If the artist, in his desire to obtain some startling or brilliant effect of coloring, persists in ignoring the imperfect means by which the result is obtained, and buys, irrespective of its true composition, some mixed-up color which will quickly and temporarily suit his aim, then his pictures will undoubtedly deteriorate.

It is a great pity that there is not some systematic and accurate method adopted in the naming of colors. Several pigments are known and sold under the same name, and an artist buying a color under that name is ignorant of its difference in composition from a second one having the same name. As an instance we may take the case of "emerald green," a name applied to two distinct and different substances yielding a green color. Some important body of artists should insist that one name only should be given to each color, and that manufacturers should supply the particular chemical substances known under that name and that only.

(To be continued.)

CONCRETE AS A FIREPROOF BUILDING MATERIAL.

Of the numerous practical questions connected with the use of concrete, probably that concerning its fire-resisting qualities is of the most general interest. Now a perfect fire-resisting material for use in buildings should possess the following qualities:

1. It should not be subject to molecular change in a fire.
2. It should be a poor heat conductor.
3. Its mechanical strength should be such that it will withstand not only ordinary structural strains, but also the strain caused by unequal and sudden heating and cooling, such as occur in fires when the hose streams are playing on the building.

Such a material would not only protect the structural metal from undue expansion and failure, but would itself be unchanged after many ordeals of fire and water.

As a matter of fact, however, no material is known which entirely meets the first requirement, and none, therefore, which can indefinitely meet the third. Good common brickwork, laid in cement mortar, meets these requirements sufficiently well for practical purposes, but entails not only considerable weight, but also segmental floor arches, to which architects object on the ground of appearances. Terra cotta hollow tiles, on the other hand, allow flat arches, but are too flimsy to meet the third requirement; they protect the steel, but suffer serious loss themselves.

Now, concrete, of various grades, covers in efficiency the entire ground between brickwork and hollow tiles. Although when subjected to heat, the cement in concrete gradually loses its water of crystallization, yet in actual fires, the process is very slow. In most cases but one side of the concrete is exposed and consequently the calcination makes little progress. Enough concrete was exposed to the fire in Baltimore to give a good idea of its behavior. On broad surfaces, the loss of water of crystallization had nowhere progressed beyond a half inch in depth, while, generally, the damage was limited to a quarter of an inch or less. The damaged material showed no tendency to come off, and would have answered as a base for a new plaster finish. On corners, where the heat was intense, the damage, necessarily, went somewhat deeper; the concrete spalled off and showed a disposition to round the corner to a radius of about two inches.

In fire-resisting constructions, if a surplus thickness of at least an inch of concrete be allowed over and above all structural requirements, and if salient angles be rounded to at least 3 inches radius, then it is certain that good concrete will pass through a number of fires before renewal or large repairs will be necessary. Fire tests made by heating specimens of concrete to 1,000 deg. F., and then cooling them, are of little practical value. In such tests brick fares little better than concrete. As a matter of fact, if the covering of the steel framework of a building is subjected to heating so intense as to produce a uniform temperature of 1,000 deg. F., the structure is practically certain to collapse, in any case. No conflagration ever causes such a condition on a large scale. In the tests mentioned, it deserves to be noticed, however, that concrete made from clean, coarse-clinkered cinders sustained little damage. Good cinder concrete has, in fact, a marvelous resistance to fire, and, at its best, is probably the most efficient available fire-resisting material. The

chief obstacle to its general use is the great difficulty of obtaining an adequate supply of the right kind of cinders. In one large Portland cement mill, using rotary kilns and the dry process, the lining of the kilns, molded from concrete made of cement clinker and neat cement, is said to be better, dollar for dollar, than the best fire-brick. It is possible that here and in the case of cinder concrete the cement may, after dehydration, become reclinkered and form as close a chemical union with the aggregate as it did in the previous process of crystallization. It may be added that broken bricks, broken slag or terra cotta are probably better aggregates for fire-resisting concretes than stone; gravel also appears better than stone, but not so good as bricks or slag.—From a paper by Capt. John S. Sewell.

[Continued from SUPPLEMENT No. 1592, page 25506.]

INTERNAL-COMBUSTION MOTORS.*

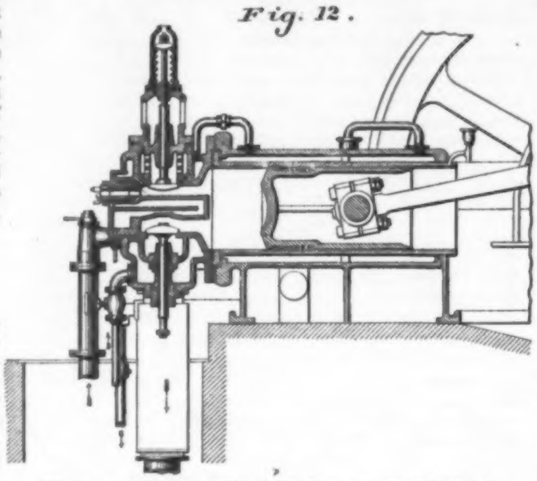
By DUGALD CLERK, M. Inst. C.E.

NOTWITHSTANDING the knowledge that our air cycle will deviate from a cycle of constant efficiency under the assumed conditions, the gas engine cycle may be considered to be fundamentally one of this nature. In all modern engines of the explosion type, the attempt is made to add all the heat as early in the stroke as possible, because heat added at the beginning is generally recognized as being more effective than heat added toward the end. This becomes evident on comparing the efficiencies obtained in actual engines with the standard efficiencies given in Table II. Table I. shows, in the column headed "E, standard air cycle," the efficiencies calculated in accordance with Table II.; that is, the efficiencies of the standard air cycle for the particular compression volume of each engine; the compression volume $\frac{1}{r}$ is given in the next column. In the column $\frac{\text{I.H.P}}{\text{E}}$ the ratio of the actual efficiency to the standard efficiency is given, and it will be seen that this varies between 0.48, in Slaby's experiment, and 0.6 in Humphrey's experiment.

This comparison of efficiency of a standard air engine with that of the actual engine is even more interesting in cases where a series of experiments have been conducted with the same engine, compression alone being varied. Such experiments have been made by Prof. Meyer in Germany and by Prof. Burstall in England. Taking Prof. Meyer's results, I have calculated out the air standard efficiency for the different compressions, which ranged between 40 pounds per square inch and 80 pounds per square inch above atmospheric pressure.

The results of this comparison are shown in Table V. The first column shows the actual efficiency, the second the air standard efficiency, and the third the

Fig. 12.



250-H. P. KOERTING 4-CYCLE GAS ENGINE.

relation between them. The fourth column shows the speed of the engine in revolutions per minute.

TABLE V.—CALCULATED FROM PROFESSOR MEYER'S EXPERIMENTS.

Actual Efficiency.	Air-Standard Efficiency.	Actual / Standard.	Revolutions per Minute.	Dimensions of Engine, etc.
0·250	0·44	0·58	257	Engine 7·8 inches diameter by 11·8 inches stroke. Compression varies between 40 lbs. and 80 lbs. per square inch above atmosphere.
0·244	0·42	0·58	249	
0·214	0·37	0·58	251	
0·188	0·33	0·57	225	

In this case, although the air standard efficiency varied between 0.33 and 0.44, the ratio of the actual efficiency to the standard was practically constant at 0.58. In the case where the number becomes 0.57, this is evidently due to the lower rate of revolution of the engine in that test.

The first and second parts of Table VI. show the actual and air standard efficiencies calculated by me from Prof. Burstall's tests* for the highest and lowest results.

The first and last columns have been taken from Prof. Burstall's tables; the second and third columns have been calculated from the details given by him.

It will be observed that all the higher efficiencies were obtained with maximum temperatures of about 1,100 deg. C. and all the lower efficiencies with temperatures of about 1,700 deg. C. In the first two tests, A^7 and B^8, the ratio is 0.57 and 0.59; in the second two tests, C^7 and D^8, it falls to 0.51 and 0.5; in A^1 and B^2 also the ratio is less, namely, 0.5 and 0.52; but in C^1 and D^1 it falls to 0.4 and 0.38.

It is interesting to compare these results with the numbers found in Prof. Meyer's experiments, where the actual efficiency divided by the standard efficiency gives practically a constant, 0.58, whereas in Prof.

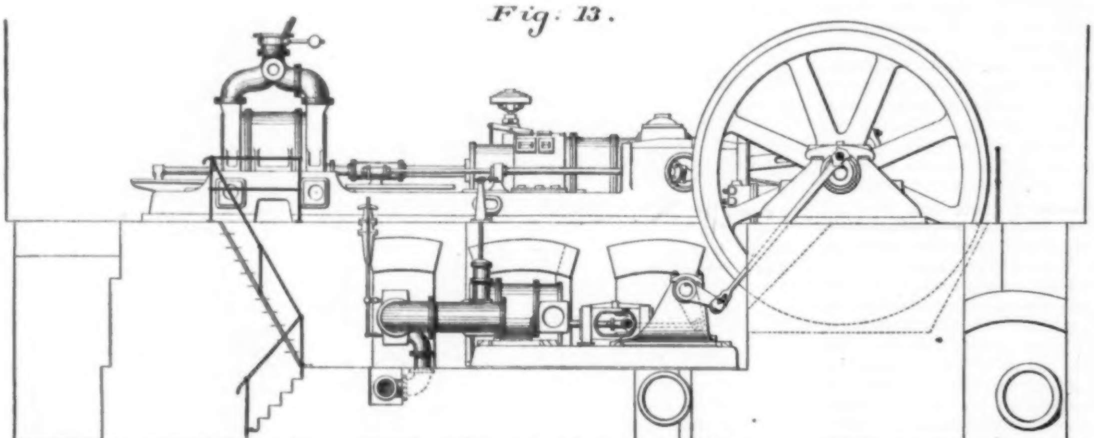
TABLE VI.—CALCULATED FROM PROFESSOR BURSTALL'S TESTS.

—	Actual Efficiency.	Air-Standard Efficiency.	Actual / Air standard.	Maximum Temperature.	Dimensions of Engine, etc.
		First.			
A^7	0·189	0·33	0·57	1145°C.	6 inches diameter by 12 inches stroke. About 200 revolutions per minute. Compression 30 lbs. to 165 lbs. per square inch.
B^8	0·212	0·36	0·59	1098°C.	
C^7	0·219	0·43	0·51	1154°C.	
D^8	0·231	0·47	0·50	1094°C.	
		Second.			
A^1	0·166	0·33	0·50	1751°C.	
B^2	0·187	0·36	0·52	1745°C.	
C^1	0·172	0·43	0·40	1749°C.	
D^1	0·181	0·47	0·38	1437°C.	

Burstall's experiments the ratio varies between 0.38 as a minimum and 0.59 as a maximum. In both sets of Prof. Burstall's experiments, at a certain stage of compression, to raise the compression to C^7, D^8, C^1 and D^1, a projecting block was attached to the piston beyond the junk ring. This produced an annulus between the combustion space walls and the projecting block, and the heat of the explosion was thus rapidly lost, more rapidly with high temperatures than with low temperatures; so that, instead of efficiency increasing with increased compression, with high temperature the efficiency actually fell, being less at high compressions than at low compressions; that is, instead of continued increase of efficiency with increased compression, at a certain point the efficiency fell instead of rising.

These experiments very clearly show the prejudicial effect of high temperatures in increasing heat losses, and also the evil effect of cooling surfaces of certain configurations.

Fig. 13.

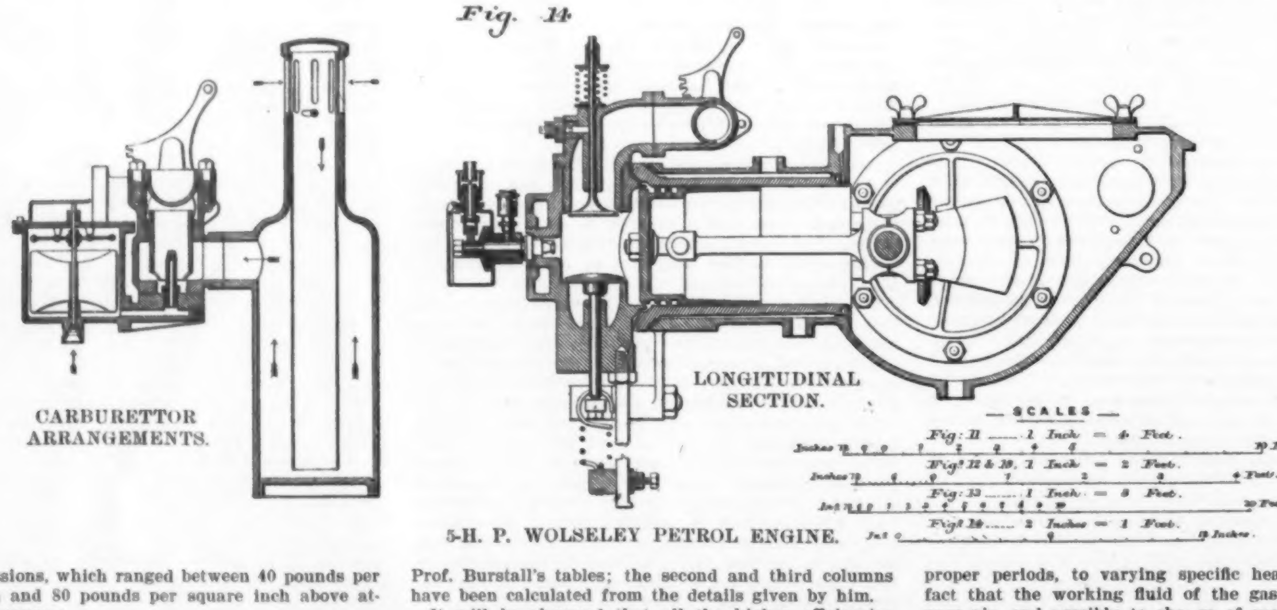


500-H. P. OECHELHAEUSER GAS ENGINE WITH BLOWING CYLINDER.

From these numbers it may be concluded that in motors of ordinary commercial construction of to-day the actual efficiencies vary between 0.5 and 0.66 of the air standard efficiencies, depending on the dimensions of the engine and the success of the designer in arranging the shape of the combustion space, and also, of course, upon the perfection of the action of the valves. The deviations of the actual from the air standard efficiencies are, of course, due to heat losses to the cylinder and piston, to heat additions at improper periods, to varying specific heats due to the fact that the working fluid of the gas engine is not pure air, and possibly to change of specific heat with changing temperature.

Many useful lessons can be gathered from these tables. From them it is evident that, under whatever

Fig. 14



5-H. P. WOLSELEY PETROL ENGINE.

* Being the "James Forrest" Lecture, delivered at the Institution of Civil Engineers, Session 1903-1904. Excerpt Minutes of Proceedings of Institution of Civil Engineers. Vol. clviii. Session 1903-1904. Part iv.

* See Reports of the Gas-Engine Research Committee of the Institution of Mechanical Engineers, 1898, p. 200, and 1901, p. 1031.

conditions the assumed air engine is operated, diminution of compression volume means increased efficiency; and from the comparisons of the actual with the air standard efficiencies it is also apparent that large engines approach more nearly to the standard efficiencies than small ones, and that loss is occasioned by high flame temperature and by improperly disposed cooling surfaces.

Although it is evident that the practical results follow the standard results with some closeness, yet much information is required before a really accurate standard engine of comparison can be formulated. Before this can be done, considerable investigation is required into the actual conditions found in gaseous explosions; and perhaps the first question which must be definitely settled is that of the specific heat of air and of the various gases which enter into the chemical action of combustion at temperatures ranging from, say, about 500 deg. C. to about 2,000 deg. C. No satisfactory de-

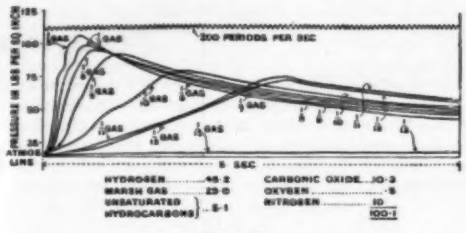


FIG. 15.

terminations have been made at these high temperatures. It is true that four distinguished French physicists, Messrs. Mallard, Le Chatelier, Berthelot, and Vieille, have attempted to obtain values of these specific heats by following the beautiful method of investigation originally used by Bunsen. They took various mixtures of inflammable gases with oxygen and air, added diluting gases such as nitrogen, carbonic acid, steam, etc., and determined the various pressures and temperatures produced by gaseous explosions in the different mixtures. From these experiments they attempted to deduce the specific heats of oxygen, nitrogen, carbonic acid, steam and other gases. To enable them to do this, they knew in the first instance the amount of heat in the shape of inflammable gas present for each explosion. They satisfied themselves that combustion was complete at maximum temperature, that dissociation was absent, and that other disturbing causes were eliminated. They then came to the conclusion that the specific heats of these gases had greatly increased at high temperatures. In my opinion these conclusions are vitiated by what I consider to be the fundamental fallacy of supposing that any mathematical examination of lines of cooling could determine with any accuracy whether combustion was completed or not. I have made many experiments on this subject, and my conclusion is that combustion is not complete when those distinguished experimenters assumed it to be so. All experience of gas-engine explosion is against the assumption of any possibility of proving changing specific heat by combustion experiments. I have made a series of experiments upon London coal-gas with a new apparatus of great accuracy. The curves produced and the analysis of the gas are shown in Fig. 15. From these cooling curves I have selected a common pressure and measured carefully the rate of cooling from that common pressure. If the specific heat be changed, then the rate of cooling will be constant from any given temperature. The choice of a common pressure means that at the particular period of time in the explosion vessel the mean temperature of the gases is the same. If the temperature of the gases be the same, and the cooling surfaces be at the same temperature, then the falling curve for all mixtures should be invariable. In Fig. 16 are

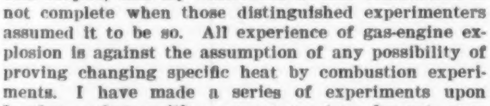


FIG. 16.

shown the falling curves superimposed one upon another from the same starting point. It will be found that they do not cool at equal rates. The rates are not greatly different, but the difference is perfectly easily observed, and it follows a rigid general law. The richer in inflammable gas, the more rapidly does the mixture exploded cool, from the same temperature; and it will be observed that in mixtures ranging from 1 in 6 to 1 in 11 the cooling curves fall more and more gradually in reverse order of the richness of the mixture. This experiment is quite inconsistent with the idea that the only phenomenon going on in the vessel at these periods is change of specific heat. Obviously in these experiments heat is being added in each case—in some cases at a greater rate than in others.

The phenomenon, familiar to all gas engineers, of a high expansion line in cases of weak mixtures also proves that some method of adding heat is present other than any mere change of specific heat. By properly proportioning the mixture in a gas engine cylinder, and firing it quite completely at the beginning of the stroke, it can be shown that almost any desired curve of fall may be obtained, up to the isothermal line; and this, of course, is quite inconsistent with the hypothesis of change of specific heat.

Physicists would do a great service to gas engineers if they would determine the specific heats of oxygen, nitrogen, steam, carbonic oxide, and hydrogen, at these high temperatures by some methods which do not involve combustion. Several methods suggest themselves. The first, and most obvious, perhaps, is to compress air or the gas to be examined in a pump-cylinder, using a heavy powerful engine of the Diesel class, driving the pump from another motor, causing the pump, to begin with, say, to take in an air charge from the atmosphere, compress it to a high degree, expand it, and reject it on the four-cycle, taking care to lubricate the cylinder with non-inflammable material. At the same time the cylinder-cover, the cylinder-walls and the piston should be water jacketed, and the heat flow should be measured in, say, five distinct sections, by causing as much water to flow through each section as would keep the discharge temperature constant. In this way, by comparing compression and expansion curves, together with heat flow, it would be possible to calculate the specific heat of air or any gas experimented upon without introducing the uncertain element of combustion at all. With a compression space of about 3 per cent and a maximum pressure of about 2,000 pounds per square inch, the temperature of about 1,000 deg. C. would be attained. The heat added in this case would be measured by the mechanical work done upon the air or other gas. Such experiments would be most valuable to the engineer; and, properly carried out, would be capable of giving very accurate results.

Another method which suggests itself, is to heat the air electrically by means of incandescent wires, at constant pressure, keeping up a flow past the wires, measuring the temperature of the air when incandescent by Prof. Callendar's beautiful instruments, and absorbing the heat of the air in a calorimeter. This method also would serve to determine positively the specific heat of air, or any other gas, at a high temperature.

Another method still suggests itself, and this method I have attempted to put into practice; it is to produce a gaseous explosion, then liberate the pressure through wire gauze in a vacuous vessel, at an extremely rapid rate—so rapid as to damp down the entire combustion,

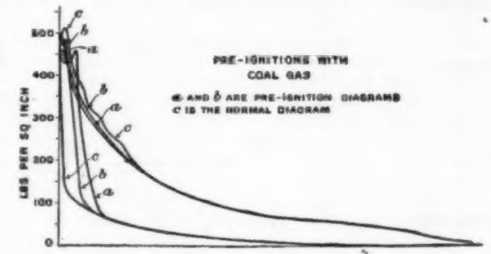


FIG. 17.

say, in about one-hundredth second—then attempt to measure the inflammable gas which was not burned, and so estimate for any given period of a gaseous explosion, either in an engine or in a closed cylinder, the amount of heat evolved at a given point.

These experiments are both troublesome and expensive; to get accurate physical constants would involve several years' work, but apart altogether from the practical use to the gas engineer, which would be very great indeed, the scientific interest alone is of a high order. They would throw important light upon our present ideas of temperature and temperature standards, in addition to settling important physical constants.

The determination of the maximum temperatures of gaseous explosions depends, to a large extent, on a knowledge of the chemical actions going on in an explosion. These actions are of a very complicated kind, and more exact knowledge as to their nature will exercise considerable influence upon the future of the internal-combustion motor. Before attempting to calculate the temperature of a gaseous explosion, from pressures produced by that explosion, it is necessary to consider the particular inflammable material used to produce the combustion, and it is especially necessary to consider the atomic and molecular volumes of the materials entering into the chemical action both before and after combustion. Assuming complete combustion, it is well known that a maximum explosive mixture of hydrogen and oxygen, or carbonic oxide and oxygen, suffers a contraction of one-third in the passage from the uncombined gases to the compounds—steam or carbonic acid. Where these substances exist in moderate amount, as in coal gas, and atmospheric air supplies the oxygen, the maximum contraction on complete combustion is not very serious. It amounts to about 2 per cent to 3 per cent. Where producer gas or water gas is used, however, the chemical contraction may be much greater. In the use of hydrocarbons such as occur in petroleum and petrol—butylene, amylene, pentane, heptane, and octane, for example—it is found that instead of contractions, molecular expansions occur. The volumes of the inflammable mixtures and the products of combustion in oxygen are given in Table VII.

Thus, with an explosive mixture of butylene and oxygen, 14 volumes become 16 volumes, and with the corresponding mixture of amylene and oxygen 17 volumes become 20 volumes. In a similar mixture of pentane and oxygen, 18 volumes become 20 volumes, and with heptane and oxygen 24 volumes become 30 volumes; with octane and oxygen, 27 volumes become 34 volumes. With alcohol again, which is now coming into use in these engines, 8 volumes of explosive mixture expand to 10 volumes on complete combustion. A mixture of air and alcohol could easily give an expansion of about 6 per cent. In this respect alone, then, all change of molecular volume between the uncombined gases and the compounds formed after combustion must be carefully examined before the temperature can be estimated, either from an indicator diagram taken from an engine or from the results of an explo-

TABLE VII.—RELATIVE VOLUMES OF COMBUSTIBLE MIXTURES WITH OXYGEN AND PRODUCTS OF COMBUSTION.

$\overbrace{2 \text{ vols. Ethylene } C_2H_4 + 6 \text{ vols. } O}^{8 \text{ vols.}}$ give $\overbrace{4 \text{ vols. } CO_2 + 4 \text{ vols. } H_2O}^{8 \text{ vols.}}$

$\overbrace{2 \text{ vols. Butylene } C_4H_8 + 12 \text{ vols. } O}^{14 \text{ vols.}}$ " $\overbrace{8 \text{ vols. } CO_2 + 8 \text{ vols. } H_2O}^{16 \text{ vols.}}$

$\overbrace{2 \text{ vols. Amylene } C_5H_{10} + 15 \text{ vols. } O}^{17 \text{ vols.}}$ " $\overbrace{10 \text{ vols. } CO_2 + 10 \text{ vols. } H_2O}^{20 \text{ vols.}}$

$\overbrace{2 \text{ vols. Pentane } C_5H_{12} + 16 \text{ vols. } O}^{18 \text{ vols.}}$ " $\overbrace{10 \text{ vols. } CO_2 + 10 \text{ vols. } H_2O}^{20 \text{ vols.}}$

$\overbrace{2 \text{ vols. Heptane } C_7H_{16} + 22 \text{ vols. } O}^{24 \text{ vols.}}$ " $\overbrace{14 \text{ vols. } CO_2 + 16 \text{ vols. } H_2O}^{30 \text{ vols.}}$

$\overbrace{2 \text{ vols. Octane } C_8H_{18} + 25 \text{ vols. } O}^{27 \text{ vols.}}$ " $\overbrace{16 \text{ vols. } CO_2 + 18 \text{ vols. } H_2O}^{34 \text{ vols.}}$

$\overbrace{2 \text{ vols. Alcohol } C_2H_6O + 6 \text{ vols. } O}^{8 \text{ vols.}}$ " $\overbrace{4 \text{ vols. } CO_2 + 6 \text{ vols. } H_2O}^{10 \text{ vols.}}$

$\overbrace{2 \text{ vols. Acetylene } C_2H_2 + 5 \text{ vols. } O}^{7 \text{ vols.}}$ " $\overbrace{4 \text{ vols. } CO_2 + 2 \text{ vols. } H_2O}^{6 \text{ vols.}}$

sion in a closed vessel. In the case of one set of chemical compounds, the real temperatures would exceed the apparent temperatures, and in the case of expanding chemical compounds the reverse is true; that is, the real temperatures would be lower than the apparent temperatures. To determine these temperatures, however, from the change of pressure, it is necessary to know definitely whether combustion be complete or not, and that is knowledge which would be gained indirectly from the determination of the specific heat referred to. It might, however, be gained directly by the explosion method of experiment which I am at present pursuing.

It is absolutely necessary, however, before any accurate standard of comparison can be formulated, to know with some exactness the real actions occurring in gaseous explosions, as bearing upon the degree of combustion at given stages of the explosions.

A further question has to be considered in this connection: in the internal-combustion motor, the cycle of operations—charging and compressing—proceeds with one set of chemical substances, and the combustion at once changes those substances into other compounds. The question then arises in calculating the heat added at constant volume, which specific heat is to be taken, the mean specific heat of the working fluid before combustion, or its mean specific heat after combustion. This question cannot be definitely answered without knowing the exact history of the change of the chemical nature of the working fluid; so that, in calculating from existing engine diagrams, it is impossible to say at present with accuracy even how much heat has been added at the minimum volume, or how much is added during expansion. That heat is added during expansion in many cases does not seem to be open to doubt; but how much heat is added depends upon a knowledge of the chemical history of the working fluid

TABLE VIII.—VALUES OF E FOR $\gamma = 1\cdot 37$ AND FOR $\gamma = 1\cdot 38$

$\frac{1}{r}$	$E = 1 - \left(\frac{1}{r}\right)^{0\cdot 37}$	$E = 1 - \left(\frac{1}{r}\right)^{0\cdot 38}$
$\frac{1}{2}$	0·23	0·231
$\frac{1}{3}$	0·334	0·341
$\frac{1}{4}$	0·401	0·409
$\frac{1}{5}$	0·449	0·457
$\frac{1}{7}$	0·513	0·523
$\frac{1}{10}$	0·573	0·583
$\frac{1}{20}$	0 67	0·680
$\frac{1}{100}$	0·818	0·826

within a period, in a large engine, of about one-sixth second, and in a small motor-car petrol engine within a period of one-twentieth second to one-fiftieth second.

These are the facts which the engineer requires before the properties of an engine can be formulated to be used as a really accurate standard engine of comparison. No doubt a somewhat closer assumption may be made than has been here made by comparing the gas engine with an air engine standard. It is known, for example, that the ratio of specific heat at constant volume to specific heat at constant pressure in many gas-engine mixtures before explosion is 1 : 1.38, and after explosion 1 : 1.37. Efficiency values can be calculated with these constants, and I have calculated them and have found the values to be slightly lower

than those for air pure and simple. A set of values for these numbers is given in Table VIII.

A calculation has been made also of the efficiency of two assumed cases of air-standard engines where expansion and compression are both adiabatic, but where the adiabatic compression follows the curve $PV^{1.38}$, and the adiabatic expansion is $PV^{1.36}$. Where the maximum temperature is 1,600 deg. and the suction temperature 100 deg. C. the efficiency is 0.446. If specific heat at constant pressure be taken at 264.5 foot-pounds, $\frac{1}{r} = \frac{1}{5}$. If the specific heat be taken as 252.4 under the same circumstances, then the efficiency becomes 0.467. In the case where expansion is $PV^{1.37}$, compression $PV^{1.38}$, $\frac{1}{r} = \frac{1}{5}$, and specific heat at constant volume 264.5 foot-pounds between 1,600 deg. C. and 100 deg. C., E is equal to 0.441. In both these cases, which closely resemble practical cases, the deviation from standard is not great.

The lessons of the simplified standard engine of comparison which has just been discussed are very clear, and gas-engine constructors have noted that among all uncertainties there emerges one certain fact, that the higher the compression—or rather, the smaller the compression space relatively to the cylinder volume—the greater is the economy to be obtained from the engine. They have seized upon this fact, and the past twenty-five years of English and Continental practice have shown steadily increasing compression. Improvement in this direction may be considered as due to bettering the conditions of the thermo-dynamic cycle; but another line of improvement is also open, and that is to reduce the heat losses to the lowest possible. All internal-combustion motors suffer large heat losses because of the contradictory requirements of the practical cycle. The cycle requires a charge of working fluid first, as cold as possible, then compression of that charge without loss or gain of heat, then combustion, producing high temperatures, succeeded by expansion, also without loss or gain of heat. In an ordinary internal-combustion motor of medium size these opposite conditions follow each other in the same cylinder at intervals of about one-sixth second, and in a high-speed petrol motor at intervals of one-twentieth to one-fiftieth second. It is, therefore, impossible to arrange cylinder conditions to minimize heat flow, because any attempt to keep surfaces hot to prevent loss of heat at once introduces heat into the working fluid at a time when it should remain cold. Some heat loss, therefore, from the hot gas to the relatively cold walls, is unavoidable. This loss, however, becomes naturally less and less with increase in the dimensions of the engine.

With engines of similar proportions, the surface exposed for cooling the flame increases as the square, while the capacity of the engine increases as the cube of the dimensions. From this it follows that the larger engines should lose less heat proportionately than the small ones. This is found to be the case, but it is also found that in engines exceeding certain dimensions the reduction of cooling-surface can be pushed too far. This is due to the fact that an engine piston has to compress an inflammable mixture to high pressure before ignition occurs at all. If the products of the previous combustion be not entirely removed, then in a large engine the temperature remains so elevated that the initial or suction temperature of the engine is raised and at high compressions pre-ignitions occur.

Fig. 17 is an indicator diagram illustrating pre-ignition in an engine of moderate dimensions under adverse circumstances.

This question of pre-ignitions limits the engine designer in many ways, and it becomes absolutely necessary to preserve the inflammable mixture during compression at a temperature below its igniting point. Any inflammable mixture only requires to be sufficiently compressed to ignite without any other means of inflammation. Unfortunately, the conditions of maximum economy in engines are also conditions which favor pre-ignition. In small engines pre-ignitions are rare and are not dangerous: in large engines they are unfortunately somewhat frequent, unless mean pressures be kept down and extensive cooling be adopted; and when they do occur they are somewhat dangerous. It is unfortunate, also, that no exact knowledge exists as to the temperature of ignition of different gaseous mixtures, and the engineer has been obliged to accumulate very considerable knowledge of the subject by the simple process of pushing compression with each gaseous fuel as high as he dare without producing pre-ignition. If with any fuel he produces pre-ignitions, then he at once alters the compression space and other parts so as to reduce the compression.

It is found, for example, that with weak gases of the producer type, such as blast-furnace gas, compressions may be carried very much farther than with very inflammable gases, such as town's gas or natural gas. In general, it may be taken that gases which are rich in hydrogen are highly inflammable, and pre-ignite readily. Such dangerous mixtures can be compressed only to a moderate degree without risk. It has been found, for example, that in petrol engines the compression can be carried higher than in heavy-oil engines, and that with some kinds of heavy oil compression must be lower than with other kinds. On the other hand it appears that, with alcohol as the inflammable material, compressions can be carried very much higher than with petrol.

At present the engineer knows, from previous experience, that, if he carries compression beyond a certain limit for a certain gas, he will at once make his engine relatively unworkable, owing to frequent pre-ignitions. The great limiting element in all internal-combustion motors, so far as high compressions are concerned, is this one of pre-ignition. Pre-ignitions are due to many causes; sometimes to a small incandescent part of metal within the cylinder; sometimes to a porous surface of metal within the cylinder; sometimes to a hot piston-end; sometimes to an overheated exhaust valve; possibly to charred matter or carbon deposited in the cylinder. In all cases, however, pre-ignition occurs owing to the tendency of these engines to be overheated. In large engines of perhaps 200 horse-power and upward, pre-ignitions are only avoided by excessive water cooling of all parts and a plentiful flow of cooling water at low temperature.

Fig. 12. Koerting gas engine (Otto cycle) of 250 horse-power. The interesting feature of this engine is the water-cooled tube inserted into the combustion space to increase the cooling surface so as to prevent pre-ignition.

Fig. 13. The Oechelhaüser gas engine with blowing cylinder, 500 horse-power. This engine operates on the Clerk cycle system. It has two pistons in one cylinder having two open ends. The front piston is locked directly by connecting rod to the crank, and the back piston is linked up to two cranks by connecting rods, side rods, and end and side cross-heads. One piston overruns ports in the cylinder for exhaust, and the other piston overruns air and gas-inlet ports. Thus no lift valves are exposed to the explosion pressure. Separate gas and air pumps are arranged under the main engine and driven by a connecting rod and bell-crank system from an outside crank.

The blower cylinder is arranged tandem with the main cylinder.

Fig. 14. Wolseley petrol motor of 5 horse-power; Otto cycle; horizontal cylinder, 4½ inches diameter by 5 inches stroke; rated speed, 600 revolutions per minute.

Fig. 15. Diagrams from explosions in a closed vessel, with London coal-gas.

Fig. 16. Enlargement of superposed cooling curves from explosion in a closed vessel, with London coal-gas.

Fig. 17. Diagrams showing pre-ignitions in a gas-engine cylinder; Otto cycle; cylinder, 10 inches diameter by 16 inches stroke; speed, about 200 revolutions per minute; hot plate attached to piston to cause pre-ignition.

(To be continued.)

FORMULÆ FOR THE WIRE TABLE.*

By Harold Pender.

In reading the article "How to Remember the Wire Table," it occurred to me that the following formulæ might prove of interest:

Let n = number of wire B. & S. gage.

Then for copper wire at 0 deg. C.:

Resistance; $R = .1 \times 2^{\frac{n}{3}}$ ohms.

Weight: $W = \frac{320}{2^{\frac{n}{3}}}$ lbs. per 1,000 feet.

$W' = \frac{1690}{2^{\frac{n}{3}}}$ lbs per mile.

Area: $CM = \frac{105600}{2^{\frac{n}{3}}}$ circular mils.

Diameter: $D = \sqrt{CM} = \sqrt{\frac{105600}{2^{\frac{n}{3}}}}$ mils.

For sizes expressed as so many ciphers, take n negative and equal to the number of ciphers less one. For example, for No. 0000, $n = -3$.

The value of 2 with any index is readily found by expressing $n/3$ as a mixed number and operating with the whole number and the fraction separately. For example, for $n = 16$,

$$2^{\frac{16}{3}} = 2^{5\frac{1}{3}} = 2^5 \times 2^{\frac{1}{3}} = 32 \times 1.26 = 40.32.$$

The following values are easily remembered:

$$2^{\frac{1}{3}} = 1.26.$$

$$2^{\frac{2}{3}} = 1.59.$$

[The formulæ given by Mr. Pender express in a different form the rules laid down by Mr. Scott. Many will doubtless find the rules more easily remembered and applied than the formulæ. The values 1.26 and 1.59 which are given above, will be recognized as approximately equal to the 1.25 and 1.60 employed in the former article.]

* Electric Club Journal.

DETERIORATION OF STORAGE BATTERIES.

In a paper on the deterioration of secondary batteries, published in the Inst. Elect. Engin. Journal, G. D. A. Parr assumes that if the plates be freed by the makers from any nitrogen compounds, the main trouble arises from impurities introduced with the electrolyte. Brimstone acid is to be preferred as being usually free from arsenic. Cells slowly lose their charge at the rate of from 1 to 2 per cent of their total capacity per diem, but this may amount to from 40 to 50 per cent if the cell contains impurities. Metals more electro-negative than lead, e. g., iron, nickel, copper, etc., are deposited on the lead, forming a short-circuited local element, and causing lead sulphate to form in the active material of the negative plate and hydrogen to be evolved. Any litharge used should be free from manganese owing to the possible formation of permanganic acid. Distilled water is best used, but the author condemns the plan of using condensed steam from boilers, or of adding small quantities of ammonium sulphate, sodium sulphate, or sodium carbonate to the electrolyte. The author is carrying out a series of tests to find out which of the common impurities in sulphuric acid or water is most harmful; at present it appears that small amounts of sulphurous acid produce the most marked effects.

STEAM AND PRODUCER-GAS TESTS OF COAL.*

The accompanying table shows the comparative results of burning various coals under the boiler and in the gas producer, and is reproduced from the preliminary report on the tests of fuel made at the plant established at St. Louis by the United States Geological Survey. Concerning these results, Robert Fernald, who was in charge, says: "It is to be recollected that the steam generated by the boiler was used in a simple non-condensing engine of the Corliss type, whose water rate was 26.3 pounds of steam per hour per horse-power-hour developed; that this engine was belted to the electric generator, and that the mechanical efficiency of this combination of engine and generator was 81 per cent. If the steam generated had been used by a steam engine capable of producing 1 horse-power-hour with 18 pounds, and if the engine and generator had been direct-connected, giving as high a mechanical efficiency as 90 per cent, then the total dry coal per electrical horse-power per hour would have been reduced from 4.3 pounds to very nearly 3 pounds. It should be mentioned that the labor required would be the same for the operation of either the boiler plant or the gas-producer plant of the capacity under test. In either plant two men would be sufficient."

In the table, Wyoming No. 2 is not anthracite, as might be supposed from the name, but bituminous coal.

The method of conducting the producer-gas tests is described as follows by Mr. Fernald: The plant installed is a Taylor pressure gas producer, furnished by R. D. Wood & Co., of Philadelphia. The producer, of 250-horse-power capacity, is 8½ feet in external diameter and 15 feet high, and is connected through an economizer, 3 feet in external diameter and 16 feet high, to a scrubber, whose external dimensions are 8 feet in diameter by 20 feet in height. The scrubber is filled with gas-house coke, which is constantly flushed with water during the operation of the plant. From the scrubber the gas passes to the tar extractor, which resembles in outward appearance a centrifugal pump. The speed of rotation of this device is of vital importance in tar extraction. After passing through the tar extractor, the gas goes directly to the purifier, an iron box 8 feet square and 3 feet 3 inches in height. This box is filled with oxidized iron filings and shavings that remove the sulphur from the gas, which next passes to the holder, a receiver a little over 20 feet in diameter and 13 feet high, of 4,000 cubic feet capacity. From the holder the gas is conducted through a meter to a three-cylinder vertical Westinghouse gas engine, with cylinders of 19 inches in diameter and 22-inch stroke, rated at 235 brake horse-power. The engine is in turn belted to a six-pole 175-kilowatt Westinghouse direct-current generator.

Although the results in many cases have been highly satisfactory, there is no question that in a second series of tests upon the same coals, made with the idea of showing the greatest economy, the amount of coal per horse-power per hour will, in the majority of cases, be much less. The results show with what ease gas may be produced from bituminous coal and lignites, and, taken as a whole, indicate the satisfactory economic results that may be expected under ordinary working conditions.

* From the Engineering and Mining Journal.

COMPARATIVE SUMMARY OF THE LEADING RESULTS OF THE COAL TESTS MADE UNDER THE BOILER AND IN THE GAS PRODUCER.

Name of Sample.	Duration of Trial.		Total Dry Coal Consumed per Hour.*		Dry Coal Burned per Square Foot of Grate Surface per Hour.		Water Evaporated from and at 212° F. per Pound of Dry Coal.	B. T. U. per Pound of Dry Coal Used.		Electrical Horse-Power Delivered to Switchboard.		Total Dry Coal per Electrical Horse-Power per Hour.*	
	Steam Plant.	Gas-Producer Plant.	Steam Plant.	Gas-Producer Plant.	Steam Plant.	Gas-Producer Plant.†	Steam Plant.	Steam Plant.	Gas-Producer Plant.	Steam Plant.	Gas-Producer Plant.	Steam Plant.	Gas-Producer Plant.
	Hours.	Hours.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.					Lbs.	Lbs.
Alabama No. 2	10.02	43.00	874	328.7	21.54	7.78	8.55	12,555	13,365	213.7	200.6	4.08	1.64
Colorado No. 1	9.97	40.00	722	341.7	17.80	7.56	7.21	12,577	12,245	149.1	200.2	4.84	1.71
Illinois No. 3	10.13	30.00	861	356.7	21.23	8.41	8.04	12,857	13,041	198.1	199.6	4.34	‡1.79
Illinois No. 4	10.02	30.00	938	348.5	23.13	7.96	7.27	12,459	12,834	195.4	199.4	4.80	‡1.76
Indiana No. 1	9.93	29.67	908	384.3	22.39	9.08	8.45	13,377	13,077	220.0	199.9	4.13	‡1.93
Indiana No. 2	10.13	7.00	832	312.0	20.51	7.13	8.02	12,452	12,933	191.0	201.0	4.35	‡1.55
Indian Territory No. 1	9.75	31.00	778	374.0	19.17	8.05	8.64	12,834	13,455	192.3	204.0	4.04	1.83
Kentucky No. 3	10.07	30.00	882	381.2	21.75	8.92	8.27	13,036	13,228	208.9	200.5	4.22	‡1.91
Missouri No. 2	9.98	4.33	1,014	299.6	25.00	7.96	7.68	11,500	11,882	205.6	198.6	4.93	‡1.71
West Virginia No. 1	9.98	24.00	768	315.6	18.94	7.36	8.95	14,198	14,306	196.7	200.4	3.90	1.57
West Virginia No. 4	10.00	9.00	770	258.2	18.98	5.96	9.65	14,102	14,302	212.5	199.7	3.62	1.29
West Virginia No. 9	10.00	6.33	721	320.1	17.78	7.60	10.09	14,616	14,580	208.2	201.0	3.46	1.59
West Virginia No. 12	10.13	30.00	719	300.5	17.68	6.92	9.90	15,170	14,825	203.6	190.8	3.53	‡1.50
Wyoming No. 2	9.95	30.00	1,075	416.5	26.31	9.50	5.22	10,897	10,656	182.0	201.2	5.90	2.07

* In gas-producer plant this includes the coal consumed in the producer and the coal equivalent of the steam used in operating the producer.
† Coal actually consumed in producer only. ‡ Gas-producer hopper leaked during these tests.

CONTEMPORARY ELECTRICAL SCIENCE.*

CONSTITUTION OF THE ELECTRON.—W. Kaufmann has repeated his measurements of the mass of the electron at various speeds with greatly increased accuracy, in order to decide, if possible, between the rival theories of Abraham, Lorentz and Bucherer with regard to the structure of the electron. As a source of electrons he used radium, and instead of an electromagnet he used two highly aged permanent magnets. He photographed the magnetic and electric deflection curves on films cast on plate glass, and compared them with the curves demanded by the three theories. The final result is stated as follows: The value of e/m for infinite slowness, as derived from cathode-ray experiments, is 1.885×10^7. The curves of deflection of the β-rays of radium, interpreted according to the theories of Abraham, Lorentz, and Bucherer, respectively, give 1.823, 1.660 and 1.808×10^7 for the same ratio. The theory of Lorentz, according to which the electron in motion is reduced in the direction of motion, but not laterally, is, therefore, least probable. The experiments do not, however, decide between the theory of M. Abraham, who assumes an absolutely rigid electron, and that of Bucherer, who assumes that the electron in motion becomes a Heaviside ellipsoid with unchanged volume, and thus incompressible. But so far, the figures support Abraham's theory.—W. Kaufmann, Sitzungsberichte der Akademie, Berlin, November 16, 1905.

CUPROSILICIUM.—In 1896, Vigouroux, by melting together copper and silicium in a Moissan electric furnace, obtained a body to which he assigned the formula $SiCu_2$. The same body was obtained about the same time by Chalmot, who heated a mixture of sand and carbon in the presence of copper in the electric furnace. But shortly afterward he found that the body was really a mixture of copper silicide and free silicium. Again, in 1901, Vigouroux obtained a compound by passing vapor of silicium chloride over copper heated to 1,200 deg., but could not make it contain more than 10 per cent of silicium. Now P. Lebeau has analyzed a sample of a commercial silicide of copper. It is slate-colored, and its fracture possesses the luster and color of silicium. Microscopical examination shows large crystals of silicium embedded in a silicide, the crystals of the latter again containing minute crystals of silicium. When powdered and treated with a 10 per cent solution of caustic soda, the silicium dissolves and leaves the pale yellow copper silicide. The latter, on being dissolved with nitric acid, leaves some very minute steel-colored crystals, which the author found to be a silicide of iron, Si_2Fe, forming 3.5 per cent of the total mass. The copper silicide has the composition $SiCu_4$, and is probably the highest silicide possessing any stability.—P. Lebeau, Comptes Rendus, November 27, 1905.

ELECTROLYTIC PREPARATION OF SPONGY TIN.—D. Tommasi describes an industrial method of preparing spongy tin, and gives figures with regard to the efficiency of the method. The electrolytic cell contains two anodes of tin, and the liquid consists of 50 parts water, 10 parts stannous chloride and one part hydrochloric acid. The cathode is a large copper disk capable of rotating in a vertical plane, and fixed for this purpose with its center to a bronze shaft. The disk is half submerged in the liquid. The upper half passes between two brass scrapers, which scrape off the tin deposit and depolarize the disk. The spongy tin is collected automatically and washed, the liquid being evaporated to the concentration of the bath and used over again. In one experiment, with a disk 30 centimeters in diameter, an E.M.F. of 3 volts and a power of 120 watts, the amount of tin deposited per horsepower hour was 380 grammes, the theoretical amount being 440 grammes. The efficiency is therefore 86 per cent. But there is no reason why disks as large as 3 meters in diameter should not be used. With a disk of that size the amount of tin deposited would be 4,400 grammes per horse-power hour, or 105 kilogrammes per day of twenty-four hours.—D. Tommasi, Comptes Rendus, January 8, 1906.

LUMINOSITY OF ELECTRIC LAMPS.—P. Vaillant has made some interesting observations on the relation between the power consumed and the spectrum luminosity in various types of electric lamps, including the mercury lamp, the carbon and tantalum incandescent lamps, and the Nernst lamp. In the Cooper-Hewitt mercury-vapor lamp he made the curious observation that the greater the power the lamp consumes the yellower is the light. Measuring the luminous intensities at wave lengths 577, 546, and 492 $\mu\mu$ respectively, he found that when the power fell from 200 watts to 99 watts, the luminosities in those three regions fell from 1,000 to 341, 398, and 449, respectively, thus leaving a distinct advantage to the blue light at the lower power. Since the blue light preponderates at the higher temperatures in all other glowing bodies, the author is forced to the conclusion that the less the power consumed the hotter is the vapor. It is certainly true that the mass of mercury evaporated diminishes as the consumption of power increases. As regards the other lamps, they all shift their maximum of luminosity toward the blue at the higher powers, and the shifting of the luminosity occurs most suddenly in the Nernst lamp. Taking the luminosity of the carbon filament for each wave-length as a standard, the Nernst lamp at ordinary working shows a deficiency both at the red and blue ends, and the tantalum lamp a great preponderance of blue over red.—P. Vaillant, Comptes Rendus, January 8, 1906.

* Compiled by E. E. Fournier d'Albe in the Electrician.

ENGINEERING NOTES.

A comparison of the performance of the compound freight locomotives with that of the simple freight locomotives is very favorable to the compounds. For a given amount of power at the drawbar, the poorest compound shows a saving in coal over the best simple which will average above 10 per cent, while the best compound shows a saving over the poorest simple which is not far from 40 per cent. It should be remembered, however, that the conditions of the tests, which provide for the continuous operation of the locomotives at constant speed and load throughout the period covered by the observations, are all favorable to the compound.

It is probable that in the wider locomotive fireboxes the main mass of the fire being so much nearer the tube-plate has a bad effect on the tubes, as the intensity of the temperature at the tube-plate must necessarily be much increased. The extra width of the box has enabled the tubes to be put much too near the sides of the barrel. When this is done, the water to feed up the spaces between the tubes near the back tube-plate has to be drawn almost entirely from the front of the barrel; and it is possible that in some cases the space left for this purpose is inadequate. It will probably be found that neglect of this consideration is the cause of three-fourths of the tube trouble. In some boilers, an effort has been made to provide for this upward circulation near the back tube-plate by leaving a space between the tubes and barrel, from top to bottom, of a sectional area equal to the combined area of the vertical spaces between the tubes at all points, with a balance to provide for the water coming back from the front of the barrel to feed the water-spaces of the fire-box.

It is practically impossible to deal with the sewage of large populated centers by means of land treatment. The area of land required satisfactorily to deal with a given volume of sewage is a question requiring careful consideration in each individual case. Full regard must be paid to the physical and other characteristics of the land, to the strength of the sewage to be treated, and to the preliminary screening and precipitation of the liquid before application to land. The depth of top soil is also an important factor as nearly all the purification is done, even in the case of porous soils, in the upper three feet of the land. The amount of rainfall upon the land also has an important bearing upon its capacity for receiving and dealing with sewage—the greatest saturation occurring just at the time when the volume of sewage to be treated is greatest. The principal classes of land met with are gravel, light loam, heavy loam, chalk, peat, and clay. On what may be termed stiff, harsh lands, experience shows that not more than a maximum of 3,000 gallons per acre per day should be flowed (usually very much less), while on the very best land obtainable a volume of 30,000 gallons per acre must be regarded as a maximum quantity. Up to these extremes all sorts of graduations of flow are met with according to the nature of the soil and other conditions.

Four methods have been used for the regulation of gas engines, these being: throttle governing; cut-off governing; variation of the richness of the charge by throttling the gas; and varying the richness of the charge by changing the duration of gas admission. The first method has the advantage of simplicity, and gives a good speed regulation, but it is wasteful of gas at low loads. The second system works very well for engines running at moderate speeds, but is not adapted to high rotative speeds, since the trip gear does not then work well. Governing by varying the richness of the mixture, the third method above noted, has been occasionally adopted, but the narrowness of the range of speed regulation gives it a limited application. The fourth method, that of varying the timing of the admission of gas, but always cutting it off at the end of the stroke at the same time, appears to be coming to the front. The principle is used in both the Körting and the Oechelhaüser engines, and it has the especial advantage of not decreasing the compression pressure. With the modern high compressions, reaching 150 pounds to the square inch or more, the particles of air and gas are brought closely together, and the heat due to compression is so high that the ignition temperature is nearly reached and the combustion is correspondingly complete.

In a discussion of the steam consumption of reciprocating engines by T. Stevens and H. M. Hobart, which appeared in the Electrical World, the engines of four English makers, viz., (A) small engines, (B) and (C) fairly large engines, and (D) large engines, are compared and expressed in terms of kilogrammes of steam consumed per kilowatt-hour output from a hypothetical direct-connected generator. The guaranteed results of these engines for a standard of absolute steam pressure 13 kilogrammes per square centimeter (185 pounds per square inch), with 50 deg. C. (122 deg. F.) superheat, and vacuum of 86.6 per cent (26 inches) for full, half, and quarter loads are plotted as curves. Curves for (D) engines with superheat of 55.5 deg. C. and 111 deg. C. are also given. From these, representative curves of steam consumption for this group of modern piston-engines are produced. Referring to Lasche's curve representing the full-load steam consumption of good modern reciprocating engines under practically the above conditions the results of the engines are plotted, and representative curves are constructed from these. Lasche's curve hardly does justice to the reciprocating steam engine for reasons which the authors state in detail, and they deduce from their investigation fairly representative curves which may be taken as a basis for the investigation of the effect on the steam consumption of modern piston-engines resulting from variations in the admission pressure, vacuum and superheat. The relations between steam consumption and admission pressure, and also the effect of superheat and that of vacuum on steam consumption, are also set forth in curves.

SCIENCE NOTES.

The technical graduate of the twentieth century will be marked by certain characteristics which are too rarely found in men trained in the colleges of literature and arts. Among these are directness of purpose, intellectual accuracy and clear thinking. The student of science and technology is trained in the realm of realities, where to commit error, to act without purpose, or to think vaguely are seen at once to be fruitful of harm. Economic and industrial needs will bring education from the cloistered lecture room into the open air of the laboratory. Technical education will have a practical, helpful bearing upon the problems of life. No longer will the seclusion of the scholar be a mark of honor. Education will be found at the bench, by the forge, in the shop, the laboratory and the drafting room, as well as in the library. The lesson to be taught will be how to apply scientific ideas to the solution of problems actually arising in the struggle to bring the forces of nature under the sway of man.

It is pointed out in an article by V. Monti in Accad. Lincei, Atti, that the determination of the velocity of propagation of a seismic disturbance from the instants of recording the maximum disturbances on the seismograms at two stations is subject to considerable error. The motion of the pendulum which traces the horizontal seismogram is a forced vibration, and the author shows that it is the resultant of a number of harmonic motions, and that the maximum displacement occurs at a time depending upon the amount of damping of the ground at the place occupied by the observatory. Thus the phase of the maximum disturbance will be different at the two observatories if the damping of the seismic disturbance is different owing to the difference in geological formation at the two places. According to the author, it is necessary to register at each station the disturbances along three axes at right angles to each other, and also the rotations about these axes, before any deductions as to velocity of propagation can be made from the relative times of recording the disturbances.

Technical education will do much toward diminishing the number of weaklings in society; the weaklings in thrift who produce pauperism; the weaklings in morals who are responsible for most of the crimes against society; and the weaklings in intellect who fill the asylums for the insane and the feeble-minded. These weaklings need less justice and more nurture. When they have broken the laws, justice imprisons them. The fundamental educational principle of the twentieth century—the education of all the people for the work of the people—will seek out these weaklings and train them to be useful instead of harmful to society. In the ordinary industrial callings the demand for technical education will exceed any bounds which we can now conservatively put upon it. Only those who make a study of the subject can realize what innumerable subjects are coming under the dominion of training. Even the Chinese, when they make railroad concessions to foreigners, insist that schools for the instruction in railway science shall be established for their benefit. In Europe there are two schools, one in Aschaffenburg, Germany, and the other in Brussels, Belgium, to teach automobilism, and a third will be opened in October at Vienna, Austria.

During the half century before 1851 scientific study was so meager and withal so theoretical that it had not reached the masses. The names of bright students and able investigators did appear, but the realm of available science was small compared with the almost boundless realm of to-day. The broad work of applying science had not begun, so that the status of technical education was extremely low, not only in England but in other European countries, and in the United States. The present high grade *technische Hochschulen*—or technical universities—of Germany and Austria, like the Berlin school founded in 1799, the Vienna school in 1851, that at Karlsruhe founded in 1825, the Munich school in 1827, Dresden in 1828, Stuttgart in 1829, and Darmstadt in 1836, were then only elementary industrial, trade, or building schools. The same was true of the present Imperial Technical Institute of St. Petersburg (1828) and the Institute of Riga (1832). The Imperial Technical Institute of Moscow was founded in 1832 in order to give the inmates of a foundling asylum a trade education. In Paris there was the Ecole Polytechnique and Ecole des Ponts et Chausées (1794). In the United States there existed only the Rensselaer Polytechnic Institute, founded in 1824, and the Lawrence and Sheffield Scientific Schools founded respectively in 1846 and 1847. In 1821 agriculture was taught in the Lyceum at Gardiner, Me., and in 1824 a school of agriculture was opened at Derby, Conn. In Sweden, the Polytechnic Institute of Stockholm (1825) and the Chalmers Industrial School at Goteborg (1811) were both in the trade school stage. The latter, indeed, was originally an adjunct to an orphan asylum. The Technical Institute at Copenhagen, Denmark, founded by private enterprise as a trade school, had just begun its work. Nowhere was there a single high-grade technical school, and in the few schools existing the technical instruction was exceedingly meager.

ELECTRICAL NOTES.

A rotating battery devised by Buhot consists essentially of two vessels joined together on the axis of rotation by a tube provided with a stop-cock. In one is placed liquid chlorine, the other being partially filled with dilute hydrochloric acid, into which dip the electrodes, consisting of disks perpendicular to the axis of rotation. The iron or zinc cathode divides the cell into two parts, communicating by openings in the electrode near its outer edge, the anodes, of platinized silver or carbon, being bound together and arranged on each side of the cathode. Slits are provided in the anodes, one edge of each being turned toward the front of the plate and the other toward the back, to facilitate the renewal of the liquid between the electrodes. During rotation, the different parts of the electrodes pass successively into the electrolyte and into the gas, and the chlorine, which is slowly admitted from the other vessel, combines with the liberated hydrogen and prevents polarization.

One of the largest wireless telegraphy stations on the Continent is to be erected by the German Aerial Telegraphy Company at Nauen, using the Telefunken apparatus. The station will be quite different from anything that has been built so far, seeing that at the Norddeich plant, which was erected for the postoffice department, we have four large towers forming a quadrilateral and over these a set of wires are stretched so as to make a funnel-like structure. Of a similar form is the four-tower station near Berlin. At Nauen, on the contrary, there is but one tower. From the top a series of transmitting wires go to the ground and form a kind of screen. No doubt less energy will be radiated here than with the system mentioned above, but it is simpler and involves a smaller capital. The tower will be 320 feet in height and it is hoped to work as far as 900 miles from the station, so as to be within reach of all the large aerial posts on the Continent, and signal to the vessels, especially of the German fleet, which are in the North and Baltic seas.

When electric motors began to be used in machine shop driving it was soon found that there were other advantages besides those of power economy to be considered. The removal of belts gave better lighting and greater flexibility in the arrangement of tools, the line-shaft being no longer the main criterion in the placing of machines. By placing tools in the natural order of the progress of the work, and by utilizing the space to the best advantage, it was found that dollars in time might be saved even when there was no appreciable gain in power cost. There is always an advantage in being able to cut off the use of power when a machine is thrown out of operation, but in any case it should be remembered that the cost of power is only about 2 per cent of the total cost of manufacture, while labor reaches from 30 to 50 per cent, so that anything which enables the work of the mechanic to be utilized to better advantage should be given first consideration. It will be seen that the argument for motor driving has tended from its first position where cost of power was alone considered, toward one in which comfort, convenience, and general economy are more important. There is a dollars and cents argument for this. Men work better and do more when they are comfortable, when light and ventilation are good. Convenience means minimizing of delay and more rapid production. There is often a greater saving from the entire elimination of small losses than from trifling reductions on the larger items of expense.

The new system of duplex telegraphy which has been recently brought out in France by M. Pierre Picard is designed to give an especially simple method of transmitting two messages over the same wire and in the same direction or opposite, without needing the use of complicated apparatus such as require the use of synchronous motors and other mechanism at each post. His invention is carried out with the object of using it at once on the telegraph lines as they are now operated in France and other countries on the Continent, where the messages are taken by Morse registers on the usual paper strip. The capacity of a given line is doubled by the use of his method. For this invention M. Picard received the Cross of the Legion of Honor and a prize from the Institute of France. As to its operation, we may imagine three posts placed on the same wire. In the ordinary way, to allow them to work, each one must wait its turn to send the messages, for the third post receives all that is sent by the other two. To carry out simultaneous transmission between the three we must employ a phonic system such as the Van Rysselberghe, but here the sounds must be taken by telephone and this would lead to a change in the apparatus. The value of M. Picard's invention lies in the fact that it can be applied in this case without changing the Morse registers. We expect to give a complete description of the system as soon as the inventor is willing to give the needed illustrations and data upon the subject. It consists essentially in the use of ordinary currents and undulatory currents upon the same wire, being a modification of the Van Rysselberghe system. The latter, as is well known, consists in rendering the make-and-break signals unheard in the telephone, and to transmit the telephone currents by means of condensers. M. Picard replaces the telephone by a special apparatus which acts as a receiver for the undulatory currents and allows these signals to be taken by a Morse register. One Morse apparatus is thus operated by a straight current and the second by undulatory current. The new system is now being used in France upon the Paris-Vichy, the Lyons-Trevoux, and several other telegraph lines.

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